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Alcohol Involvement in Snowmobile Fatalities in Canada

DJ Beirness, DR Mayhew, and HM Simpson

Traffic Injury Research Foundation of Canada, 171 Nepean Street, Suite 200, Ottawa, Ontario, Canada K2P 0B4

ABSTRACT

While the incidence of alcohol involvement in highway crashes has been well-documented, considerably less attention has been paid to the role of alcohol in fatal crashes involving off-road vehicles. Alcohol is commonly consumed in conjunction with recreational activities. If the use of a motor vehicle is involved, the risk of crash involvement would undoubtedly increase. This presentation examines the incidence of alcohol use among fatally injured operators of one particular class of vehicles - snowmobiles.

The presentation will examine data on fatal snowmobile crashes in Canada from 1987 through 1992. During this period, a total of 497 persons died in such crashes. Fatally injured drivers accounted for 82% of this total; passengers represented 13% and pedestrians 5%. Among fatally injured drivers who were tested for alcohol, 79% had been drinking. The characteristics of the crashes and the drivers involved will be examined. The implications of the findings in terms of programs and policies will be highlighted.

INTRODUCTION

The popularity of snowmobiling as a recreational activity has increased dramatically over the past decade. For example, between 1984 and 1992, the number of registered snow vehicles in Ontario more than doubled -- from 169,172 in 1984 to 366,730 in 1992 (Ontario Ministry of Transportation, 1994). Snowmobile enthusiasts in Ontario have formed 284 local snowmobile clubs as well as a provincial association. These clubs operate and maintain an expanding network of over 35,000 km of groomed snowmobile trails throughout the province. In addition, the Ontario government has invested millions of dollars towards the creation of a trans-provincial trail system to help create an environment conducive to safe and accessible snowmobiling. The economic impact of snowmobiling on the Ontario economy alone is expected to exceed $500 million this year.

The growth in snowmobiling, however, has been associated with increased concern about deaths and injuries as a result of snowmobiling crashes. For example, in 1987, 58 persons in Canada died in snowmobile crashes. In 1993, 98 persons died. The actual number of injuries as a result of snowmobile crashes is elusive. In Ontario, the Ministry of Transportation reports an average of about 400 persons injured in snowmobile crashes each year. Because not all snowmobile injuries are necessarily reported to the police, these figures are undoubtedly a severe underestimate of the true incidence of snowmobile-related injuries each year. Data from a recent survey of snowmobilers (Rowe et al., 1993) suggests that the actual number of snowmobile-related injuries in Ontario exceeds 7,000 per season -- more than 17 times the official figures.

The behaviour of snowmobile operators appears to contribute to a substantial number of crashes. Speeding, riding at night, travelling in unsafe areas (e.g., on lakes, roadways) and alcohol use have been identified as factors associated with a high risk of snowmobile crash involvement (Beirness et al., 1994;

1995; Erikson and Bjornstig, 1982; Rowe et al., 1993; Rogers et al., 1990).

The use of alcohol by snowmobile operators has become an issue of increasing concern. Alcohol is commonly consumed in association with recreational activities. When the activity happens to involve the operation of motor vehicle, the combination can have particularly tragic consequences. In recognition of the inherent dangers of operating a snowmobile under the influence of alcohol, the Criminal Code of Canada indicates that it is an offence to operate any type of motor vehicle -- including motorized snow vehicles -- while impaired or with a BAC in excess of 80 mg%. It does not matter whether the vehicle is being operated on a public roadway or on private property. The law and its penalties are applied to snowmobile operators the same as they are to drivers of highway vehicles.

This paper examines the extent of alcohol involvement in snowmobile fatalities in Canada during the seven-year period from 1987 to 1993. The characteristics of the crashes and victims are also examined.

METHOD

The primary data were obtained from the Fatality Database of the Traffic Injury Research Foundation. These data include the results of toxicological tests for the presence and amount of alcohol among persons fatally injured in motor vehicle crashes in Canada as contained in coroners' files. Data on snowmobile fatalities were collected from all provinces and territories in Canada for the years 1987 through 1993.

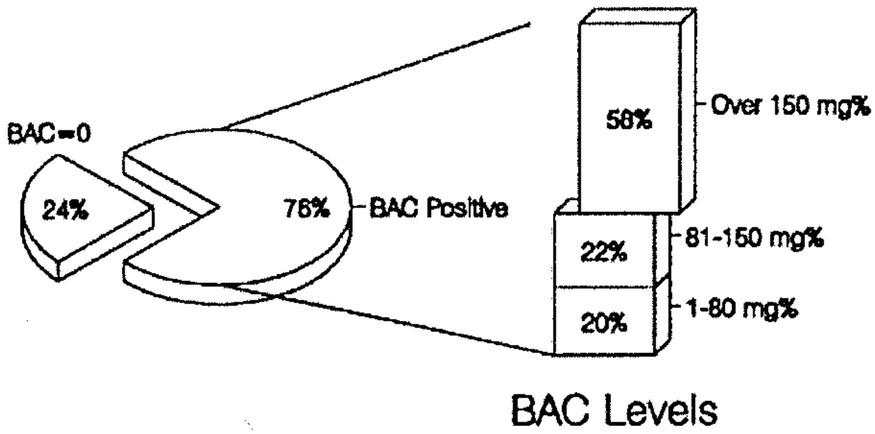
RESULTS

In total, 586 persons died in snowmobile crashes in Canada during the seven-year period from 1987 to 1993. Vehicle operators accounted for 82% (480) of the fatalities, while passengers represented 13% (75) and pedestrians 4% (24). Overall, 71.5% of all fatally injured victims of snowmobile crashes were tested for alcohol and 75% were found to have consumed alcohol prior to the crash. Among fatally injured drivers of snowmobiles, 75% were tested for alcohol and 76% of these cases were found to have alcohol present. The remainder of the paper focuses on alcohol use among fatally injured snowmobile drivers and the characteristics of the crashes in which they are involved.

Driver Alcohol Use

Figure 1 shows the incidence and level of alcohol use among fatally injured snowmobile drivers in Canada. The bar on the right of the figure shows the alcohol level among positive cases. Twenty percent of fatally injured snowmobile operators who had been drinking had a BAC under the legal limit (i.e., 80 mg%). A further 22% had a BAC between 81 and 150 mg%. By far the largest group of fatally injured drinking drivers had a BAC in excess of 150 mg%. This high BAC group comprised 58% of all fatally injured snowmobile operators who tested positive for alcohol.

Figure 1
Alcohol Use Among Fatally Injured Snowmobile Operators

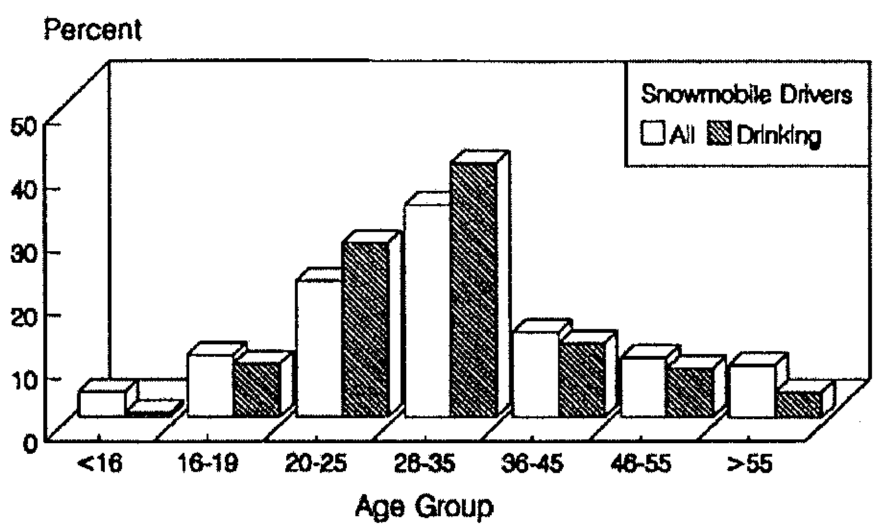


Canada, 1987-1993

Age and Alcohol Use

Figure 2 displays the percent of all snowmobile driver fatalities in each age group (represented by the open bars) as well as the percent of all drinking driver fatalities according to age group (represented by the striped bars). It is apparent in the figure that 20-35 year-olds comprise the majority of all snowmobile operator fatalities. In fact, 55% of all snowmobile operator fatalities are in this age group. Among snowmobile operator fatalities who had been drinking, 40% were between 26 and 35 years of age and a further 28% were between 20 and 25 years of age.

Figure 2
Percent of All Snowmobile Driver Fatalities and Drinking Driver Fatalities According to Age



Canada, 1987-1993

Gender and Alcohol Use

Overall, men comprise over 95% of all persons killed in snowmobile crashes. Men also account for over 95% of all fatally injured snowmobile drivers and 95% of fatally injured snowmobile drivers who had been drinking.

Among fatally injured male snowmobile drivers, 76% were found to have been drinking. Even though women comprise a very small proportion of snowmobile fatalities, 73% of female snowmobile drivers tested positive for alcohol.

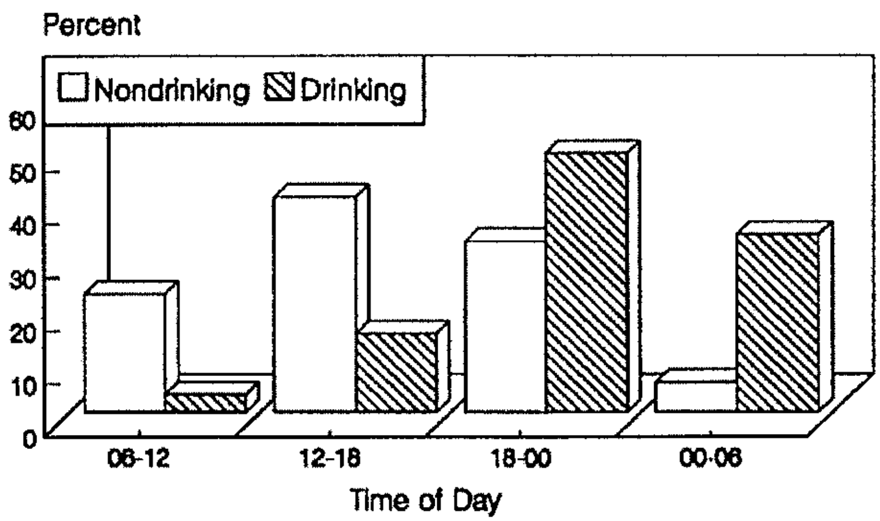
Characteristics of the Crash

Just over two-thirds of all snowmobile fatalities occurred as the result of a crash involving only a single vehicle; over three-quarters of drinking driver fatalities were the result of single vehicle crashes.

Among drinking driver fatalities, 70% occurred as the result of either a collision with a fixed object or by going through the ice on a lake or river. Collisions with another vehicle (other than a snowmobile) accounted for 18% of drinking driver fatalities and 33% of non-drinking driver fatalities. Collisions with another snowmobile accounted for 12% of both drinking and non-drinking snowmobile driver fatalities.

Figure 3 shows the distribution of drinking and nondrinking snowmobile driver fatalities according to the time of crash. It is apparent that nondrinking drivers were more likely to die during daylight hours (i.e., 6am to 6pm) and drinking drivers were more likely to be killed between 6pm and 6am. In fact, almost half of all drinking driver fatalities occurred between 6pm and midnight.

Figure 3
Percent of Drinking and Nondrinking Snowmobile Driver Fatalities According to Crash Time



Canada, 1987-1993

DISCUSSION

In the past, there has been a strong tendency to restrict one's perspective on impaired driving to situations involving passenger vehicles on public highways. The data presented in the present paper highlight the fact that the problem does not end where the road stops. In fact, the proportion of alcohol-related snowmobile operator fatalities (76%) is considerably higher than among fatally injured drivers of highway vehicles in Canada (i.e., 48%: Mayhew et al., 1995).

Specific countermeasure initiatives are needed to address the common practice of consuming alcohol as part of recreational snowmobiling. Although there is a role for increased enforcement of drinking-driving laws, the isolated areas in which snowmobiling tends to occur renders enforcement efforts difficult and inefficient. Therefore, education programs outlining the high risk of operating a snowmobile after drinking delivered through local snowmobile clubs, manufacturers, suppliers, and retailers at the community level may be the most efficient and effective means of generating awareness and concern about drinking and driving among snowmobile operators.

ACKNOWLEDGMENTS

TIRF's Fatality Database is jointly sponsored by the Canadian Council of Motor Transport Administrators and Transport Canada.

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Snow Glow Inc./ CPSC Petition

May 30, 2002
Bruce Enderle
SAE Snowmobile Committee Chairman

A brief review of the petition filed by Snow Glow Inc to the CPSC on April 9, 2002 reveals that Mr. Lakosky feels his state legislators are "inept" (letter to Governor Ventura, March 24, 1999). The manufacturers, SAE, SSCC and ISMA are all (big business) against him, against the little guy and each time Snow Glow is rebuffed, they turn against that party and begin "mudslinging".

Because the Snow Glow petition does not include even one accident report, I have chosen to look into one of their pieces of supporting documents and see if there are any underlying facts.

One of the newspaper articles (News Tribune, Sunday Dec. 9, 2001) attached as a "supporting document" to the petition, lists the WI. 2000~2001 snowmobile accident (fatalities) analysis. It states "8 of the 26 (fatalities) were a collision with another snowmobile". In fact, there were only 5 (fatalities)[1] out of the 26 that were listed as "snowmobile to snowmobile collisions" and two of those 5 were the same accident (2 fatalities, one accident) so, in reality there were only 4 cases of snowmobiles colliding with another snowmobile. Of the other 3 fatalities, one was listed as "Victim hit stop sign and another snowmobile", and the other 2 listed as "collided" with another snowmobile. There were 4 other accident reports listing "struck by another snowmobile" but these were cases where people, who had been separated from their snowmobiles, were struck by another snowmobile. They were then technically "pedestrians", and should have been listed as "struck by snowmobile", not struck by "another" snowmobile.

A review of the MN, MI and WI states fatalities for the 2000/2001 season does show incidents of snowmobile to snowmobile collisions, however, I was unable to find one incident out of all reviewed fatalities where it stated "snowmobile impacted while parked due to inability to be seen". There is one fatality on 2/10/01 in Marshall County, MN[2] where three stopped snowmobiles were impacted by a fourth rider and one of the other operators was killed. I have no more details as to time of day, line of sight or other causation factors.

[1] "Wisconsin DNR Snowmobile Incident Report 2000-2001"
[2] Minnesota DNR "Snowmobile Fatalities 200-2001 Season"

In the same newspaper article, there was an anecdotal statement from Sheriff Wahlberg of St. Louis County, who stated "Many law enforcement officials... say many, if not the majority of snowmobile accidents, are never reported."
This is unsupported and contradicted by the various states laws.
Minnesota has a $500.00 loss or any injury or fatality reporting requirement.
Michigan is "injury/ fatality or $100.00 loss".
Wisconsin *is any "reportable" accident meaning, "any injury/ fatality accident* requiring a physicians care."

The above is a very brief review of only one portion of the Snow Glow petition. It does show however, that the research that should have been done, has not been done. If Mr. Lakosky and Ms. Robillard had looked into statistical evidence, as I had requested them to do on numerous occasions for the SAE Snowmobile Committee discussions, they would have seen that there are many more serious and higher incidence statistics associated with snowmobile accidents and injuries.

The Snow Glow petition and purported supporting evidence, want the CPSC to make some "leaps of faith" in that because there are night time accidents, then it must be that some could be prevented with their lighting system. As it currently stands, snowmobiles are equipped with lighting systems and reflectors. Many, if not all, current snowmobile clothing also features reflective stripping or patterns. Their claim is that if the Snow Glow system were adopted by manufacturers or mandated by government, we would see a reduction in accidents. Firstly, they would need to have proof of these accidents (they don't) and then some supporting evidence that their system would have any effect on the outcome of these accidents. My personal belief is that the predominant causation in fatality snowmobile accidents is alcohol. The statistics bear this out. If, in fact, these hazard lighting systems were to be adopted, they may have a very negative effect. There are statistics that show that drunken automobile drivers often drive directly into parked autos and police cruisers on the roadside with their hazard flashers illuminated, it is the "moth to the candle" scenario.

As the CPSC did with ATV's, in forming their background as to regulation of the industry, they conducted "I.D.I.'s" (In Depth Investigations). Part of this involved the reviewing of accident reports to see if there were any "patterns" of accidents that were identifiable as hazards. In dealing with Ms Robillard for our SAE meetings, I had asked her to bring to the committee any statistical evidence she could find (DNR accident reports, CPSC statistics, etc...) She either did not know how to go to these respective web sites, or refused to. Anyone can access the various state and federal government sites and review this material (see attached MI, MN & WI 2000-2001 snowmobile reports). Instead, Ms. Robillard brought to the SAE Snowmobile Committee a "survey" which had been posted on the Snow Glow web site. She claims this is her "proof" of the need for hazard lighting on snowmobiles. I advised Ms. Robillard and Mr. Lakosky at our Oct 11, 2001 meeting that, their survey shows a "desire" not a "need" and that is what the aftermarket is for.

It is apparent that Snow Glow is attempting to "mandate" their product rather than sell it. If they were truly interested in safety, they would never mention their brand name, conduct the necessary research and suggest/recommend some lighting parameters with known safety effectiveness.

Ms. Robillard will tell any and all of her "first" experience on a snowmobile (it was at night) when she had a close call while stalled in the middle of a snowmobile trail. What she fails to tell people is that she had not taken an operator's safety course and had little idea of what she was doing. She has made this her "crusade" to help her boyfriend (now business partner) sell his hazard lighting system.

If the CPSC wants to further the investigation of this petition, they will find the same lack of supporting factual basis for "hazard warning lights" on snowmobiles that my limited research turned up. A parallel could be drawn to motorcycles and they are not required to have hazard lighting systems and they include battery systems to support lighting already.

I have maintained my file and correspondence from Snow Glow in this matter and it can be made available if the need arises.

I

COMMITTEE *Correspondence*

Oct 16, 2001

Al Lakosky/ Michelle Robillard
Snow Glow Inc.
312 2nd Ave. North
Virginia, MN 55792

Al and Michelle,

Thank you for your interest in snowmobile safety. The committee has reviewed your position and other similar systems. We have found no statistical support for standards writing on this issue.

SAE Snowmobile Committee,

Bruce Enderle

Bruce Enderle
Chairman

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Visibility Study - Methodologies and Reconstruction

Ernest Klein and Gregory Stephens
Collision Research and Analysis

ABSTRACT

Often as part of accident reconstruction the question of visibility arises. Examples range from a simple daytime obstruction to the more complex case of nighttime human perception. With these cases, it is often necessary to analyze the visibility aspects of the accident situation and determine if a reasonably alert person would have been able to detect certain objects associated with the accident. In order to analyze the accident situation, a method for studying various visibility aspects is needed.

The purpose of this paper is to present a methodology to study visibility aspects of an accident. It will present field reconstructions of both daytime and nighttime accidents, and unique examples illustrating target detection factors and how they can lead to an increase in visibility at night. The methodologies will include still photography, video and motion pictures. While daytime visibility studies will be addressed, the main portion of this paper will concentrate on the nighttime visibility studies.

INTRODUCTION

In accident reconstruction, the leading or contributing factors to an accident experience can usually be categorized as one of the following:

- Human factors - The driver and his interaction between the vehicle and the surroundings.
- Environmental factors - The highway, it's surface, weather conditions, etc.
- Vehicle factors - Performance or mechanical failures.

When considering visibility issues in accident reconstruction, the primary factors are human and environmental. These two factors are the foundations from which all of your study, research and analysis of that issue should originate. There has been extensive research dedicated to analyzing the human and environmental factors and how they relate to visibility issues.* It is extremely important that the details of each factor be researched as a part of the preparation for a study and/or analysis.

In certain accident situations, it is important to determine if adequate visibility was present for one or both of the vehicle operators. For example consider the following:

- Two vehicles approaching an uncontrolled, perpendicular intersection in the desert during the daytime. Can each of the drivers see the other? How about at nighttime?
- A disabled truck parked partially on the roadway is clearly visible at noon on a sunny day, yet how discernible is it at night in the rain?
- A tractor/trailer is in a turning maneuver as an approaching vehicle runs into it. How well can it be seen at night? What factors determine its conspicousity? How about under rainy conditions at night?

In order to answer these types of questions and others, a systematic method must be followed to study these situations and then present the findings in a reliable manner. The media used most frequently to convey visibility of an accident site

* Please see list of references for examples.

is photography. In order to study the accident, it is important to be able to reproduce the conditions that the driver saw. This paper will discuss and illustrate the use of a control for this purpose. A detailed description of the proposed methodology for daytime, nighttime and special situations will be introduced.* This will be followed by illustrative examples of case studies and finally a discussion of the proposed systematic method will conclude.

GENERAL PREPARATION

In order to perform a daytime or nighttime visibility study, some general preparations need to be made with regard to the accident scene, vehicle(s), and/or pedestrian(s). The accident scene needs to be substantially similar to what it actually was at the time of the accident. This includes all of the environmental factors that may effect the visibility in the study. Examples include buildings/structures, trees, utility poles, extra vehicles (parked or moving), and/or signing fixtures (warning, directional, informational, etc.). If the scene at present does not contain the same facilities that were present at the time of the accident, then the items necessary to make it substantially similar should be added or removed. If the preparation is for a visibility study at nighttime or in a special situation, then the artificial lighting facilities should be made substantially similar as well. Finally, in both daytime and nighttime visibility studies, arrangement for traffic control may be a necessity.

Now that the scene is essentially similar to that of the time of the accident, exemplar vehicles and/or pedestrians exhibiting similar characteristics as the subject vehicles and/or pedestrians need to obtained. It is very important that the car, truck, motorcycle, bicycle, etc. and/or pedestrian utilized as the object of the visibility, exhibit similar color, size, shape and general reflectivity of the subject vehicle and/or pedestrian. Generally, vehicles should be the same make and model, as well as similar size, shape and color characteristics. If the preparation is for a visibility study at night or in a special situation then the headlights on all of the vehicles will need to be state certified or adjusted to the accident setting (if known). With pedestrians, a mannequin or an exemplar person may be utilized, however it will be necessary to assure that the gender, size and color of clothing are substantially similar to that of the subject pedestrian. It is imperative that the source of visibility exhibit proper viewing height whether it be a exemplar vehicle or the known eye height of the subject pedestrian.

Lastly, time positions can be obtained by performing a preliminary reconstruction (speeds and distances) prior to the execution of the visibility study. Should perception/reaction enter as one of the issues of the study, pre-determined times and positions can lead to a straightforward study.

THE USE OF A CONTROL

Often in scientific research, large amounts of data are collected for the purpose of analysis. This data is not necessarily meaningful unless it is compared against data that does have meaning. For example, 300 pounds is an amount that does not have a lot of meaning until related to a forty-year-old male who, by comparison to the weight of a 50th percentile forty-year-old male, is overweight.

This comparison concept is the basis of the methodology described in this paper. The human eye has an extraordinary capacity for seeing very small details, faint amounts of light, and minute variations between objects. However, it is very poor at estimating absolute values. For example, under ideal conditions the eye can see a difference in the brightness of two areas that differ by as little as one percent. But even an experienced photographer has great difficulty estimating the

* Special situations include dawn/dusk, fog, and rain.

actual finite amount of light in a room within 100 percent of its true value[23].

We can take advantage of the eye's outstanding ability to discriminate detail in recording the scene as it actually appears. In a nighttime visibility study, the photographer has no need to know the absolute value of the light if a Polaroid photograph is taken and used as a **control**. Likewise, in a daytime visibility study the photographer has no need to know the values of the colors if a photograph is taken of the subject with a color card in view; in which case the card becomes the **control**. This **control** will stay constant from beginning to end of the visibility study. Using a **control** provides a reliable means of attaining full control over the entire chain of photographic variables. Figure 1 is a flowchart demonstrating this chain and the purpose of the **control**.

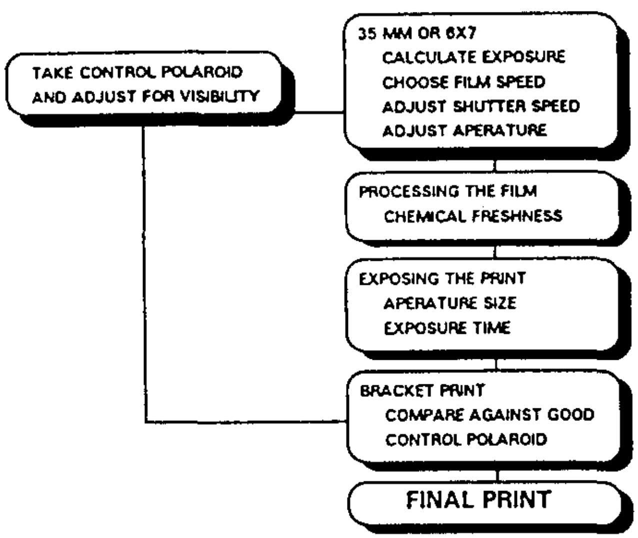


FIGURE 1

The other advantage of this method is the reduction of potential errors. The photographer can immediately make a direct comparison of the primary object in its natural background to the **control** polaroid and modulate the exposure accordingly *while at the scene*. This eliminates light meter errors, adjustments in film processing, and/or return trips. It also eliminates variations due to weather changes such as cloud cover, rain, fog, etc. if two or more trips are needed to complete the task. The use of this **control** polaroid is essential to maintain the chain of continuity between the accident scene and the final photograph as demonstrated in Figure 1.

DAYTIME VISIBILITY

Daytime visibility studies are usually relatively simple. Most often, the limitations of visibility during the day have to do with obstructions. Human perception, as it relates to the detection of colors and contrast is a factor; however the most important factor is the environment. After the general preparations have been made, the execution of the study should be prepared. A point of reference has to be assigned. For example, the point of impact (if known) is one good reference. Times and distances from a point of impact are values that are easy to understand by any person analyzing the study.

When preparing the photography, video acquisition, and/or motion picture equipment, it is important to note that the selection of the equipment is not as important in a daytime visibility study as it is in a nighttime visibility study. For a daytime situation, depending on the extent of the study, the following equipment will be needed.

First, an instant camera with variable aperture and shutter speed, such as a Polaroid 195 or a Konica Instant-Press, will be needed for location documentation. Color polaroids are recommended for daytime use because of the factors involved with color detection.

Next, the still photography equipment needs to be prepared. An SLR camera that is equipped with a 50mm lens, will be needed. Typically, 50mm lenses are utilized for visibility studies because of their ability to closely represent the optics of the human eye at normal viewing distances.

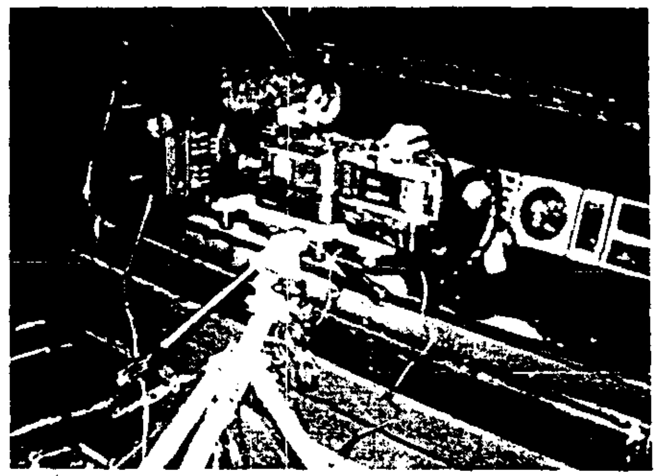
If the study warrants video or motion picture documentation for presentations such as a stop motion animation, then it is suggested that research into the preparation of such presentations should be pursued. As far as the scope of this paper is concerned, high quality consumer or commercial grade video equipment should suitably perform the necessary functions of replicating daytime visibility.

NIGHTTIME VISIBILITY

Nighttime visibility studies can be very complex. In addition to the general visibility study preparation, a few additional items need to be considered as well. A future date and time with similar natural lighting conditions should be selected. This is done by obtaining the tide tables for the time of the accident and for the present. Then a correlation of the lunar data is constructed between the time of the accident and a future date and time. If done correctly, this new date and time will exhibit similar lighting conditions to the time of the accident. If the accident involved a question of visibility of a sign then the actual sign in question or a comparably worn sign, if available, needs to placed in the same position as at the time of the accident.

The equipment for the nighttime visibility situation should be chosen carefully. It should be noted that due to exposure times and other photographic necessities, a tripod will have to be placed at the proper height in the vehicles to support the photographic, video and/or motion picture equipment. All of this equipment can be placed on the same tripod by means of a multi-mount.

Color photographs are produced by exposing a three layer film inside a camera. Lens aperture and camera shutter speed determine the amount of light that will reach the film. If too much light reaches the film, the negative will be overexposed. If too little light reaches the film, the negative will be underexposed. What is preferable is just enough light to reach the film to produce the best exposure. One note however, caution needs to be exercised when the exposure times begin to exceed approximately 1 second. The reason for this is that the linear relationship between exposure time and film speed often diminishes in this longer exposure period as the reciprocity effect appears. Compensating for this effect often results in longer than otherwise normal exposures to produce accurate photographs.



MULTI-MOUNT WITH PHOTOGRAPHIC EQUIPMENT

As discussed earlier, in order to obtain a photograph which accurately corresponds to the conditions observed at the accident site by the driver/rider and by the investigator, there are several variables in the photographic procedure that must be controlled either individually or collectively.

During the taking of the photograph - Film speed, aperture size, shutter speed.

During the film processing - Chemical freshness.

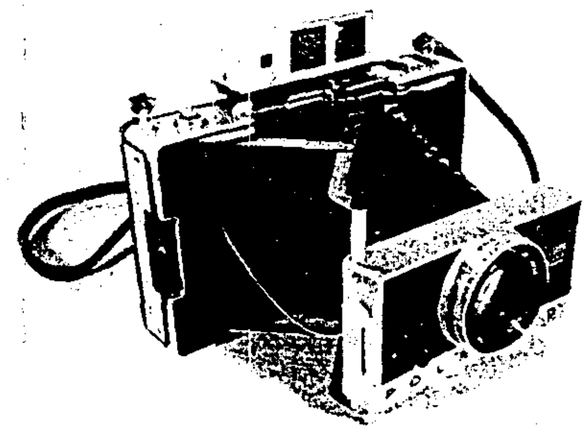
During the printing of the negatives - Paper type, enlarging lens/aperture size, and exposure duration.

It is extremely important that the final photograph depict the objects viewed as they are seen under the actual available illumination level and type. For example, headlight color differs from those of sodium lamps, and high pressure sodium lamps differ from metal halide lamps and mercury lamps. As the color rendition of light sources differ, the perception of objects viewed may also vary depending on the color of the primary object, its background, and the nature of the visual noise. Documenting this quality of discrimination can be achieved by a careful comparison of the reconstructed scene with a polaroid photograph of the same scene developed at the site. Black and white polaroids are ideal for that purpose due to (1) the high speed of the film (3000 ASA), (2) its good grain construction, and (3) its high contrast quality. If color rendition is important, a color polaroid can be taken as an additional control.

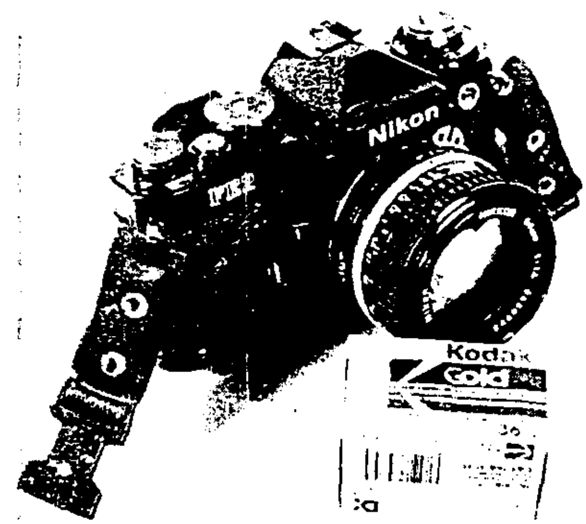
An instant camera with variable aperture and speed, such as the Polaroid 195 or Konica Instant-Press, will be used to produce the control polaroid. A good control polaroid is obtained by comparing the objects of visibility in the polaroid under a flashlight to the reconstructed scene. It is important that the objects of visibility are utilized in making the comparison. Additionally, a flashlight is utilized to avoid dark adaptation while examining the polaroid. Once a good control polaroid has been achieved then it is necessary to record the speed and aperture on the reverse side of the polaroid since this correct exposure and data will remain constant throughout this process.

35mm / 6x7 FORMATS

In the still photography preparation there are two different formats that may utilized; (1) 35mm and (2) 6x7 format. The 35mm format is the most common. This format is the most popular because it provides the widest range of various speed films and the widest aperture in the lens selection. A 35mm SLR camera with a 1:1.4 50mm lens, such as the Nikon FE2 pictured, will be needed for this preparation.



POLAROID MODEL 195 INSTANT CAMERA



NIKON FE2 WITH 50mm 1:1.4 LENS

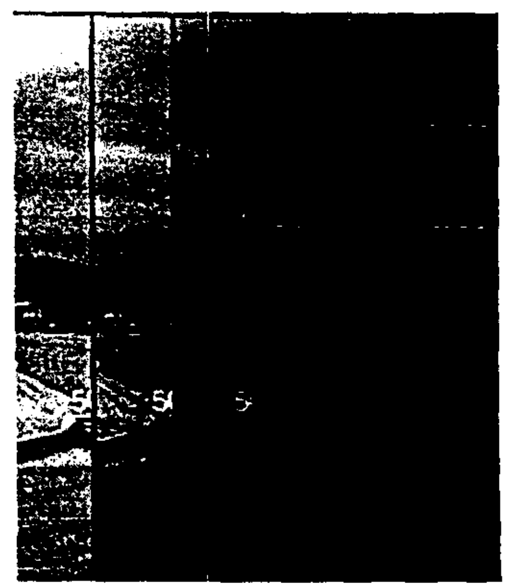
In the film selection there is a compromise between the desirable shorter exposures and the need for good grain content. In consideration of both print and slide film, 400 ASA Kodak print film was found to be a good choice. This film needs approximately three times more light than the polaroid film. For example, if a good control polaroid is arrived at with a 1/2 second exposure time for an aperture setting of f4 for 3000 ASA film; then a corresponding settings for 400 ASA film would be an aperture of f1.4 for 1/2 second. In other words, a three stop increase in the aperture was performed to accommodate the extra light needed to properly expose the film.

The second format that may be utilized is a 6x7 format. Using a 6 x 7 format camera allows a larger size negative to be obtained. A larger negative is desirable because it renders better picture definition. Greater depth of field, and reduced flaring of light sources are achieved by the available lens selection. A SMC Pentax 6x7 camera with a 45 mm F4 lens and Kodak Vericolor 400 print film is a good choice.

SMC PENTAX 6X7 WITH 45mm 1:4 LENS

Under certain conditions, photographs with superior quality can be produced using the 6x7 format cameras and lenses. However, these photographs require special attention. Due to the lens type and slower film speed, longer exposures are often required that can range between 15 to 30 seconds depending upon conditions and prevailing illumination. Also, excessive traffic may have a negative effect on background illumination under certain conditions.

In both formats, after the negatives have been properly exposed and then developed, a bracketed print needs to be constructed. A bracketed print is produced by exposing sequential lighting levels across the print. This print is then compared to your good control polaroid and the exposure time which best corresponds to the polaroid is selected. The print that results from this selection should best correspond to the conditions the night of the test. Therefore the picture will be an accurate representation of the visibility available during the study and consequently the visibility during the accident.



(longer ----------------------------------shorter)
exposure time

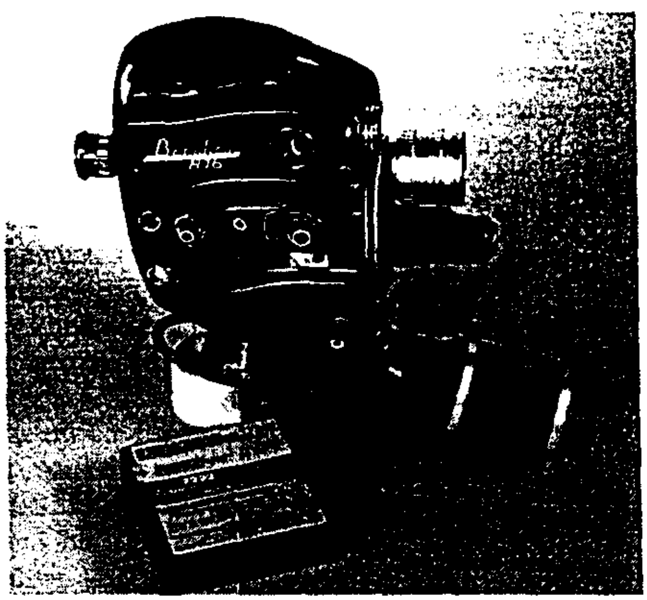
EXAMPLE OF A BRACKETED PRINT

MOTION PICTURES / VIDEO

Often a dynamic representation of a visibility study is desired. Motion pictures and video are the media used for this purpose. For motion picture preparation a 16mm motion picture camera, such as the Beaulieu R16 with a roll of high speed (ASA 320) 16mm film pictured below, is utilized. It is extremely important that high speed film is obtained for this type of dynamic representation. The method for exposing the motion picture film is very similar to that of still photography. Once a good control polaroid is obtained, the frame rate is calculated by adjusting the exposure time for the lower film speed and using this equation:*

$$\text{Frame Rate} \approx \frac{0.4}{\text{Exposure Time}}$$

Depending on the conditions the calculated frame rate may need to be adjusted. A frame rate under approximately 6 frames per second is usually not desirable because of the dynamics involved. When the proper exposure is calculated to be under 6 frames per second then reduce the exposure time in the equation by one, two or three stops, whichever is necessary to produce a reasonable frame rate. When the film is developed have the processor "push" develop the film the amount of stops that it was reduced by. It should be noted that "pushing" in excess of three stops is not recommended due to the adverse effect on the grain size.



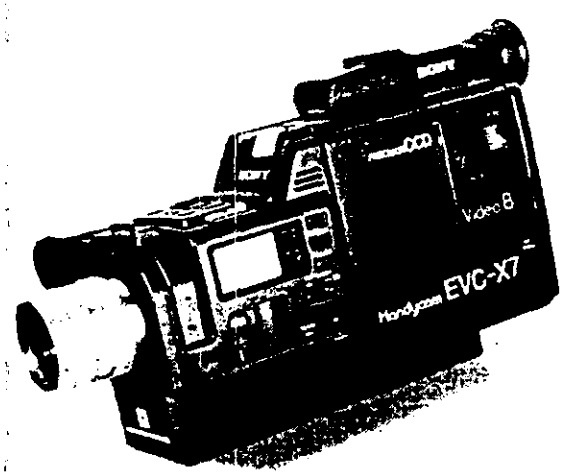
BEAULIEU R16 WITH EASTMAN 7292 FILM

* Please consult the owners manual of the motion picture camera utilized to obtain the proper relationship.

After the proper negative is obtained a positive film needs to be produced. This is done by utilizing a Hazeltin machine together with the good control polaroid and obtaining printing values for exposure and color settings. The finished product will be a film that can be viewed using a 16mm projector.

Video technology can also be utilized as well. For this preparation a special low light, C-mount video camera, such as the Sony EVC-X7 with 1:0.95 C-mount lens, is recommended. To achieve the proper exposure under low light levels, the aperture will usually need to be adjusted fully open. However, compare the good control polaroid to the viewfinder of the video camera to ensure proper exposure. The recorded videotape is then viewed on a monitor. The monitor is compared against the good control polaroid and adjusted to achieve a good match.

As mentioned earlier, motion pictures and video can also be utilized in a stop motion animation presentation of nighttime visibility. If desired, research into such presentations is suggested.



SONY EVC-X7 LOW LIGHT CAMERA

SPECIAL SITUATIONS

In addition to daytime and nighttime situations there are some situations that require some different preparation and execution. These situations include dawn, dusk, fog and rain.

DAWN / DUSK

For dawn and dusk visibility studies some additional general preparation needs to be done. The sunrise and sunset times from the tide tables for the date of the accident and the present need to be obtained. With dusk/dawn situations it is very important that the similar time with respect to the sunrise or sunset be selected for the study. It must be noted that the natural lighting changes very quickly in these particular types of studies, so proper preparation and quick execution is essential.

Similar to nighttime visibility studies, a good control polaroid needs to be taken of the object. If the object of visibility is in the foreground of the sun then adjust the control polaroid to meet the visibility. In other words, if the observer can see certain details of the object then adjust the control polaroid to reflect those same details. This is performed by decreasing the aperture and exposing the negative properly for the object.

Once the good control polaroid has been obtained then follow the procedures outlined in the nighttime visibility section to attain a good representation of the visibility of the dawn/dusk situation.

FOG

Research on visibility studies in fog is limited. However, fog visibility tests have been conducted to determine visibility distances in various forms of fog. For example, two fog density scales were developed in Italy and West Germany and are illustrated in figure 2[18].

Performing visibility studies in the fog require preparation that is currently unavailable. With a fog induced accident it is difficult at best to ascertain the identical conditions that were present at the time of the actual accident. In addition, adding the complexity of a nighttime situation to the fog and attempting to perform a visibility study is not only very involved but also could be very dangerous. It is suggested that more research be performed in establishing safe and reliable methodologies for studying visibility in fog environments.

	ITALY VISIBILITY DISTANCE (m)		GERMANY STANDARD VISUAL RANGE (m)	
TYPES OF FOG	MAX	MIN	MAX	MIN
MIST	1000	330		
THIN FOG	330	150	1000	500
MODERATE FOG	150	50	500	200
THICK FOG	50	20	200	100
VERY THICK FOG	20	10	100	50
FOG WALL	10	0	50	0

FIGURE 2

RAIN

In preparation for a rain visibility study, some additional preparation needs to be made. The precipitation records for the date and time of the accident need to be obtained. After the general preparation has been arranged, future dates need to be monitored for rainfall activity.

In this type of situation, it is important that all the preparation has been made well in advance and all equipment and personnel needed for the study are ready at a moments notice. Care should be taken with any equipment exposed to the elements.

Similar to the dawn/dusk situation, the rainfall activity may change very quickly, so proper preparation and quick execution is essential. Again, once the good control polaroid has been obtained, then follow the procedures outlined in the night visibility section to obtain a good representation of the visibility of the accident scene in the rain.

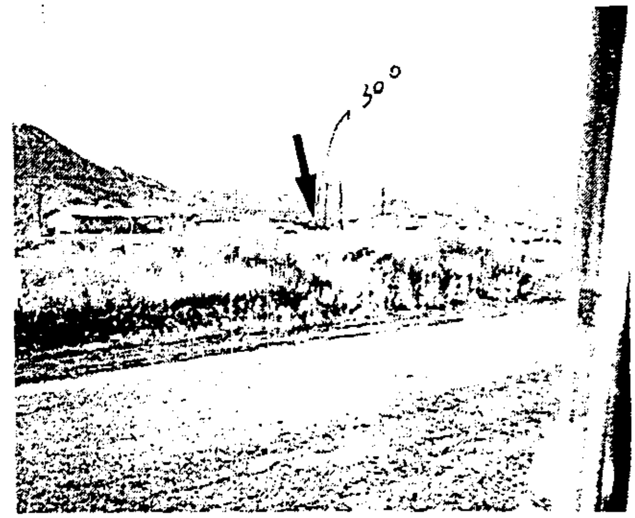
CASE STUDIES

CASE #1

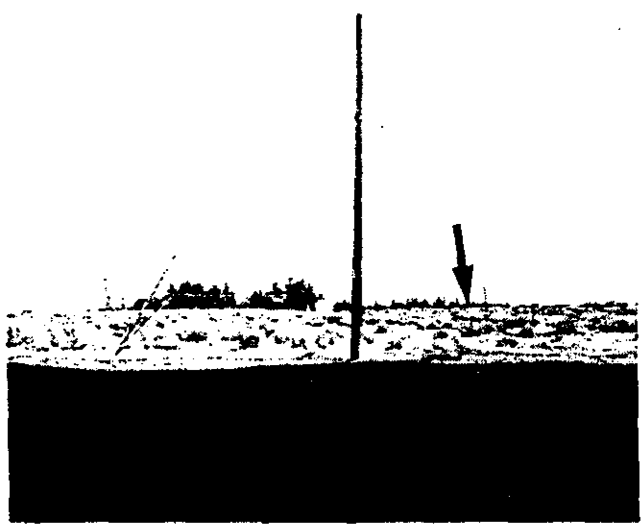
A typical daytime visibility situation occured when two vehicles approaching an intersection, in a rural desert setting, collided in the middle of the intersection. The issue was whether the drivers could see each other in time to avoid the collision. For these type of situations the following factors are of extreme importance: the nature and degree of obstruction, size, color of the vehicles, and the contrast of the vehicles to their surroundings. In this particular situation color control becomes significant.

An accident reconstruction was performed to obtain speeds and distances. The exemplar vehicles were placed at specific distances away from the intersection, corresponding to their reconstructed speeds. Then photographs depicting each of the driver's viewpoints were taken at these placements.

The following two photographs depict each of the driver's views at 91 meters (300 feet) from the intersection. The first photograph shows the white Volkswagen's approach and the second photograph depicts the brown sedan's approach.



VIEW FROM VOLKSWAGEN



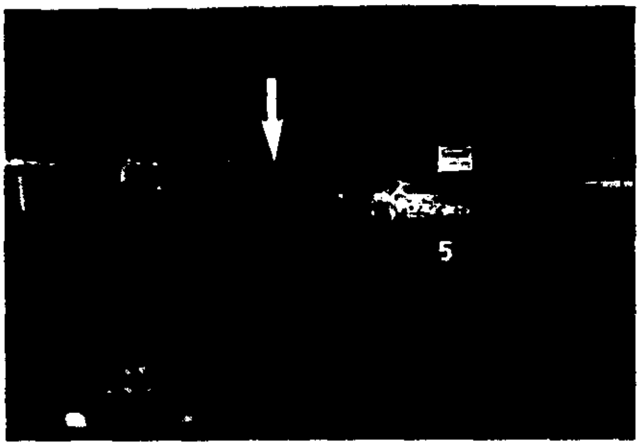
VIEW FROM BROWN SEDAN

It was shown that even though the desert background had some veiling characteristics, the vehicles were discernable approximately 91 meters (300 feet) from the intersection. It was also shown that the veiling charateristics of the desert background were further reduced when the vehicles were placed in motion. Therefore the target detection factor was enhanced in this study.

CASE #2

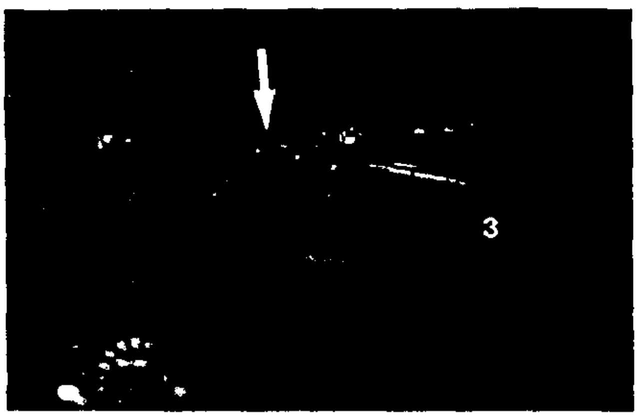
A milk truck turning left on a two lane highway was struck by an oncoming motor vehicle. A visibility study was performed using identical vehicles under similar conditions that existed on the night of the accident. On the night of the accident, the truck's wheels were white. The test truck had blue wheels so its trailer's rear wheels (location of impact) were painted white to match. The wheels of the adjacent axle were left blue for comparison and research purposes. An oncoming vehicle was positioned behind the turning truck similar to the actual accident.

Numbers in increments of hundreds of feet were placed on the right to identify the distance from the truck. Photographs were taken using the described control methods. The car was tested using both its high beams and low beams.



VIEW AT 152 METERS (500 FEET)

Pictured above at 152 meters (500 feet) with high beams, the tanker reflects back sufficiently to identify it as an object that is across the lane of travel. Additionally, the side marker lights are clearly visible.



VIEW AT 91 METERS (300 FEET)

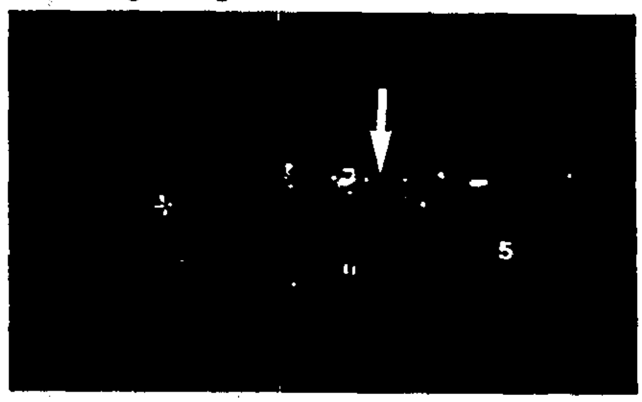
At 91 meters (300 feet) with high beams the white tractor can be detected. In addition, the white rim on the trailer is clearly visible. The same rim is also discernible from this distance with low beams. From closer distances, previously seen details become increasingly pronounced and all of the other truck and trailer features can be easily detected.

The appearance of the blue and white rims were of special interest. The white rim was able to be seen from a substantially greater distance than the blue one. This illustrates the various reflective characteristics of the different colors.

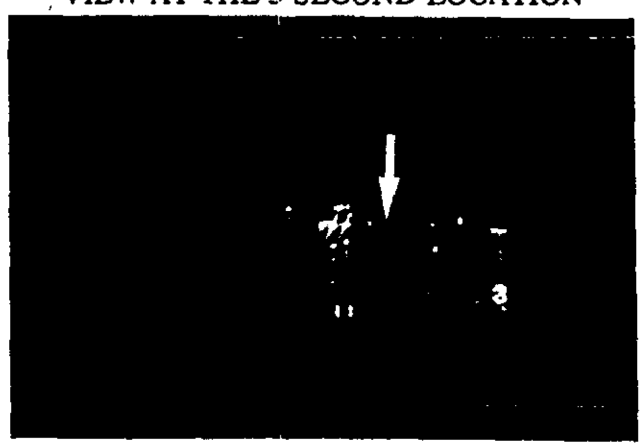
CASE #3

A tractor trailer combination was in the process of parking in a private drive on a rainy night. As the driver maneuvered his truck into the parking space, an approaching vehicle with functioning headlights collided with the trailer. All of the tractor and trailer's lights were functioning as well.

A detailed reconstruction to determine the speed of the approaching car was performed prior to this study. The speed was used to determine the location of the car and the time, at that location, along the approach, prior to impact. During the study, numbered placards were placed to the right to represent the time, in seconds, prior to impact. It was raining just prior to the test and light rain was falling during it.



VIEW AT THE 5 SECOND LOCATION



VIEW AT THE 3 SECOND LOCATION

This study indicated that the details of the tractor/trailer, particularly lights and reflectors, could be detected and associated with the actual vehicle from about the 5 second location at 64.4 km/h (40 mph) under wet conditions. The rims of the tractor are discernible at the 5 second location and the definition of the trailer is seen by the 3 second location.

CASE #4

This case involved an analysis of a reflectorized roadway fixture to evaluate its performance. A stop sign which was claimed to be positioned beyond the driver's horizontal visual field parameter of 10 degrees was evaluated.

The scene was modified to duplicate the same conditions that were present at the time of the accident. The recently installed reflectorized pavement markers were eliminated, lights were reduced to the previous levels, and an identical exemplar vehicle with state certified headlights was used.

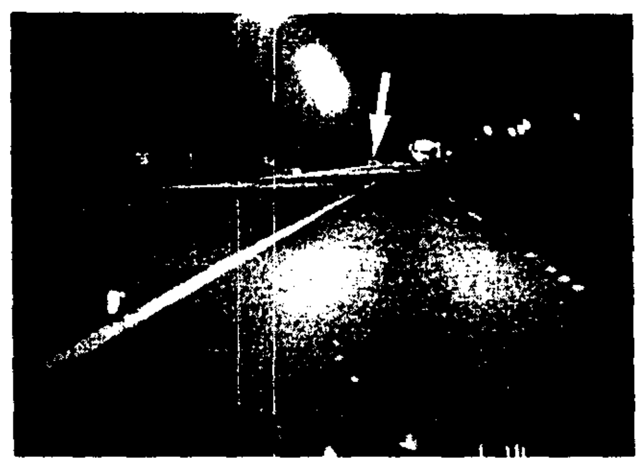
VIEW FROM 91 METERS (300 FEET)

The research was conducted and it was determined that even though the reflectorized sign was placed beyond the distance recommended in the published literature, the sign attracted sufficient attention for easy detection, recognition, and identification. The subject stop sign was detectable from close proximity up to approximately 274 meters (900 feet) away. Additionally, the octagonal shape of the back side of the stop sign for the opposite direction was clearly identifiable from a distance of 300 feet away. This would be an additional indication to an approaching driver that the intersection is stop controlled. Given the above considerations, it is difficult to explain why a driver would not be able to perceive the stop sign, due to sign placement.

CASE #5

Hi Mast illumination is being used on freeway interchanges with greater frequency. Typically, high mounted metal halide light sources are utilized to provide superior light distribution and uniformity ratios. This particular case involved the visibility of a light-colored Volkswagen with only sixty percent of the luminaries functioning in the Hi Mast fixture.

In preparation for the visibility study, the illumination of the accident scene was decreased to 60 percent efficiency. An exemplar vehicle was positioned at the impact location with it's lights on. Calibrated photographs were taken at particular distances approaching this location to depict the visibility of a oncoming driver.



VIEW FROM 136 METERS (445 FEET)

This study revealed that even with only 60% of the luminaries functioning, the vehicle could be detected from approximately 183 meters (600 feet).

CASE #6

A pedestrian was crossing a highway at night near an expressway overpass and was hit by an approaching pickup truck. The geometry of the expressway overpass formed a vertical curve and the pedestrian was crossing under a luminary which was functional at the time of the accident.

A full scale study using the prescribed methods was set up to evaluate both the geometric and nighttime sight limitations, if any, from both the pickup driver's and the pedestrian's point of view.

The results indicated that in this instance, the pedestrian had an advantage over the truck driver in terms of visibility. Once the pickup driver had proceeded to the point where the overpass is no longer an impairment on visibility then the ability to detect, identify and recognize the presence of the pedestrian on the opposite side of the road became available.

DRIVER VIEW AT APPROXIMATELY 72 METERS (235 FEET)

Although during the daytime the pedestrian would have little or no indication of an approaching pickup truck behind the overpass until it had crest the hill, at night time the conditions are different. The *headlights* of the approaching truck are visible from quite a distance. In addition, the reflection of the headlights off of the bridge railings and guardrails further announced the presence of the truck.

PEDESTRIAN VIEW BEFORE TRUCK CRESTS HILL

With these additional target detection factors present only during the nighttime, the pedestrian's visual perception of the approaching pickup truck is actually significantly greater than the driver's view of the pedestrian. In essence, the pedestrian's sight distance for the detection of the truck is *improved* at night.

CASE #7

Auto-pedestrian collisions have been studied under various conditions. In this particular case, two pedestrians were walking on a two lane rural highway at night against the flow of traffic. Both were dressed in blue jeans and white T-shirts. The accident occurred when two vehicles, with low beams on, were approaching the pedestrians from the rear and one vehicle was passing another. When the passing vehicle moved into the opposing lane of traffic, it struck the pedestrians.

A study was set up to evaluate the visibility of the driver in the passing vehicle. Identical vehicles and exemplar pedestrians wearing similar clothing were utilized. Placards were placed on the side of the road indicating the distance from the zero reference. Additionally, any glare from oncoming vehicle's headlights was not disturbed.

Calibrated photographs were taken at various distances away from the pedestrians to determine at what point full and partial visibility was attainable. The photograph below depicts the view at approximately 91 meters (300 feet) from the zero reference and 76 meters (250 feet) from the pedestrians.

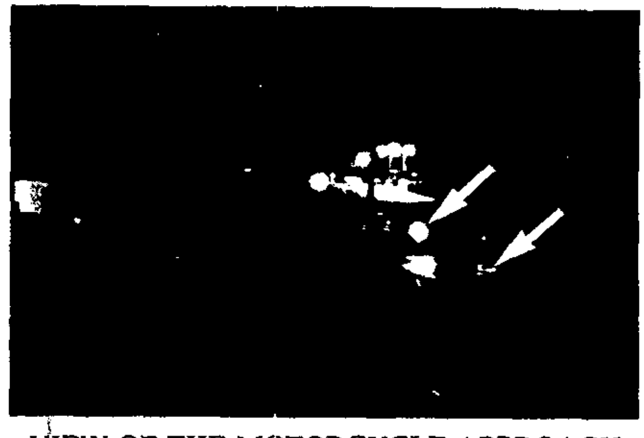
VIEW AT 91 METERS (300 FEET)

The results of the study indicated that the pedestrians could be detected and identified from a distance of approximately 122 meters (400 feet) or less with partial detection from slightly greater distances. Partial detection was attributable to the white T-shirts worn by the exemplar pedestrians.

CASE #8

A passenger vehicle was in the process of making a left turn from a local street, which had a stop control, onto a major arterial, having two lanes in each direction. A motorcycle was approaching from the left of the passenger car and the two collided. A utility pole was located in the quadrant between the two vehicles.

A study was setup to determine the effect the utility pole had on the visibility of the motorcycle during the night of the accident. An exemplar motorcycle with a state certified headlight was utilized. The motorcycle was placed at various locations along its approach and calibrated photographs were taken.



VIEW OF THE MOTORCYCLE APPROACH

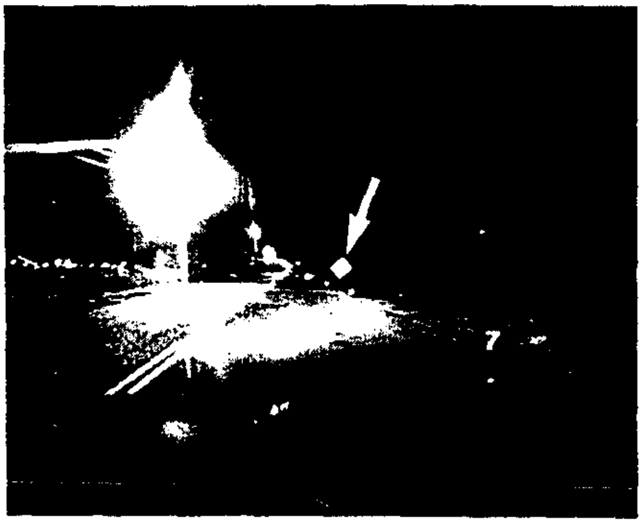
The results of the study indicated that prior to the headlight moving behind the utility pole, the beam of the motorcycle headlight was reflecting off the roadway surface in front of the pole. Additionally, the beam of the motorcycle headlight created a "halo" effect when it moved behind the utility pole. In other words, light was visible on both sides of the utility pole.

CASE #9

Construction-zone accidents are of special interest. In these type of situations, equipment, traffic routing, signing and the construction zone itself must be carefully addressed. In this particular case, a vehicle traveling into a construction-zone at night, drove through warning signs and barricades and collided with a piece of construction equipment.

A study was performed to evaluate the visibility of the barricades, reflectorized pylons, and a road construction sign that was used past its rated life span. An exemplar vehicle with state certified headlights was utilized in providing the driver's visibility perspective. The subject sign and the other construction facilities were placed at the same locations that they were at the time of the accident.

The results of the study indicated that the construction-zone had more than adequate warning sign facilities. Moreover, a careful evaluation of the road construction sign revealed that although it was utilized beyond its rated life span, it still maintained useful reflective properties and provided acceptable levels of warning.



VIEW OF THE SUBJECT SIGN

VIEW OF ADDITIONAL BARRICADES

CASE #10

A bicyclist riding a small BMX bicycle at dusk was struck as he turned right at an intersection by an approaching Cadillac. The bicyclist had a posted stop sign for his approach and yet failed to stop despite the approaching Cadillac which had the right of way.

A visibility study was set up to evaluate the visibility considerations of both the Cadillac driver and the bicyclist. The subject Cadillac and an exemplar bicycle that was not equipped with headlights, reflectors, nor functional brakes were utilized. The vehicle and bicycle were placed at locations based on a reconstruction of the accident. Calibrated photographs and video using the prescribed methods were then taken from each of the operator's viewpoints. The photograph below depicts the driver's view at approximately 1 second prior to impact.

DRIVER VIEW 1 SECOND PRIOR TO IMPACT

The results of this study related that under the conditions of the subject accident, it was nearly impossible to discern the non-illuminated bicycle that had no reflectors on it, in comparison to detecting the approaching Cadillac with its headlights. The Cadillac was much more conspicuous and detectable than the small and fast moving bicycle, particularly at the correlated dusk period.

DISCUSSION

As illustrated through the case studies the task of detection depends greatly on a number of different factors. Generally categorized, those factors are human and environmental.

The environmental factors consider items such as the expressway overpass (CASE #6) and utility poles (CASE #8), as well as the typical line of sight, daytime visibility situations. In these considerations, the geometry of the scene is of great significance in evaluating the visibility. This underlines the importance of fully reconstructing the accident scene to what it was at the time of the accident, prior to performing the visibility study.

The human factors are more complex by nature. These factors encompass elements relevant for detection such as acuity, contrast, form perception, color, etc. As mentioned earlier, extensive research has been performed in these areas for specific situations. The significance of the prescribed methodology is that it *condenses* these factors into a single yet precise comparison concept. In essence, this concept directly evaluates the target value and conspicuity of the subject.

Target value is the capability of the subject to be visible against its background and to provide early recognition and discrimination[40]. To evaluate the target value, a visibility assessment of the object against its background needs to be made and then reproduced, using the described methodology, for later analysis.

Target values can be increased or decreased by a number of different factors. For example, in certain situations rain can actually improve the task of detection (CASE #3). When water builds up on the roadway surface the reflectivity of the surface increases. Another example of improved detection is a condition called silhouette lighting. A dark object against a brighter background is readily detectable, particularly if the object is in motion. Items such as a glaring sun or headlights from a oncoming vehicle may cause discomfort or disability glare, thereby reducing the detection threshold of an object. It is factors such as these or similar factors that can adversely affect the target value.

Conspicuity is the property of a peripherally located object that is likely to lead to the object's detection and subseqent foveal fixation (and identification) by reason of its size, luminance, constrast, or other physical properties[36]. This idea is noted in a number of the case studies and is for the most part a common property. An example is the stop sign in CASE #4 positioned to the right beyond the recommended range. Due to the reflectorization and it's color, shape and size, the stop sign dominated the accident scene ahead. This property of the sign would lead to a reasonable detection distance by any approaching vehicle.

As noted earlier, the eye has a remarkable capacity for seeing minute variations between things. In evaluating the target value and conspicuity, the prescribed methodology produces a control, such as a polaroid, and makes a comparison against the actual scene. An important point of the methodology, is that the object of visibility is utilized for the comparitive purposes.

CONCLUSION

A method has been presented by which the reconstruction, documentation, and presentation of the visibility at an accident scene is controlled and reproduced with remarkable accuracy.

The concept of a control was introduced as the basis for this accurate reproduction. It relies on the human eye's unique capability to discern minute differences in brightness when used on a comparatory basis. It was shown that this method can be successfully used both in day and night situations, and may be used to control the reproduction of the accident scene onto still photography, motion pictures, and video.

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890730

Nighttime Photography — Show It Like It Is

Robert D. Holohan, Alan M. Billing, and Stephen D. Murray
Arcon Engineering Consultants Limited

ABSTRACT

A technique is presented to produce a photograph that accurately illustrates the limits of perception for an observer's view of objects under night lighting. This may be used to show others the results of an investigation of visibility problems associated with a nighttime collision. The method, which involves the observer viewing signs of varying shades of grey at the site under appropriate conditions, and the production of a range of photographic prints from which the correct density level is selected, is described. Findings from validation testing are discussed including the expected accuracy and possible difficulties.

PHOTOGRAPHY OF A COLLISION SITE is a frequently-used and widely-accepted means of illustrating circumstances observed by a person investigating or reconstructing a collision. Few persons have difficulty recognizing features that may appear in a daytime photograph, such as trees and signs that may obstruct a driver's vision, and it is relatively easy for even an amateur photographer to produce a colour photograph acceptable at face value as representing the appearance of the scene.

It is far more difficult to illustrate what a driver or other observer may have seen during darkness or under conditions of low illumination, since there is no straightforward procedure for exposing and printing film, that will produce a print that accurately represents the observer's view. Even in low lighting such as that commonly provided by a vehicle's headlamps, it is not difficult to produce a photograph that shows the scene well into the distance almost as clearly as by daylight; and another print could be produced showing inky blackness.

An obvious method that has been used involves suitable photographs being taken at the scene and printed at a variety of densities. An observer then returns to the scene under identical conditions and selects that photograph corresponding most closely to its appearance. This can be cumbersome (requiring two site attendances under correct conditions), and is subject to substantial difficulties in comparing the poorly-lit scene with the photographs, which must be viewed at a higher level of illumination. The process is limited by the required dark adaptation of the human eye. A further disadvantage, from an engineering point of view, is that it relies upon the observer's judgement with no standard by which its accuracy can be judged. This is a particular problem in the case of a potentially biased observer or an observer not familiar with procedures of this nature.

Previous efforts involved placing a series of signs comprising black numerals on a white background, at set intervals from the foreground to the background past the items of interest. The limit of visibility was taken to be the most remote sign for which the number could be recognized. This, or a quite similar, method has been used or advocated by others (1,2)*.

Placing signs between the foreground and the background can be helpful in establishing a representative photograph in some circumstances, but often presents three major disadvantages. The procedure is not feasible in locations where the signs cannot be positioned in a clear line of sight suitably ahead of, or beyond, the objects of interest. In situations involving artificial lighting, the sign at the limit of visibility may be under significantly different illumination than the objects of interest, which may result in a disproportionate relative prominence in the reproduction. The procedure does not readily accommodate a means to minimize possible bias on the part of the observer.

* Numbers in parentheses designate references at end of paper.

In view of these difficulties, a systematic method was developed through a number of iterations to allow the production of a photograph that, subject to limitations discussed below, can be demonstrably equivalent to the view of a particular observer in night visibility. During its development, characteristics and limitations of the method have been examined.

VISION AND PHOTOGRAPHY

A person with an interest in recording an observer's nightime view is usually concerned with the limits of perception, in investigating conditions under which an object, such as a pedestrian, a parked automobile or a road obstruction, may just be visible. This involves consideration of the effect of illumination, background contrast, object size and other factors. The work reported here is directed only to the problem of providing suitable illustrative photographs, after determination of the visibility conditions.

A search of the literature identified little other work that specifically addressed techniques to produce photographs corresponding to an observer's nighttime perception. The subject involves several inter-related areas of specialization, including the physiology of the eye, psychological aspects of perception, low-illumination sensing, and photography.

The human eye/brain sensory and perceptual systems are complex, but extensively studied (e.g. 3,4). It is well known that the eye has two types of sensors, called rods and cones. The cones are particularly dense around the fovea, at the back of the retina, and, under "daytime" light levels in excess of about one millilambert, they provide what is known as photopic vision with high-resolution colour detail. At lower light levels the cones become progressively less effective; the contribution by the rods becomes relatively greater; and resolution decreases. Scotopic or night vision is pure rod vision below about 0.01 millilambert down to the lowest threshold of vision. Night driving encompasses a wide range of luminance levels, largely within the intermediate range known as mesopic vision (5).

While cones are sensitive to colour, rods are not; further, rods and cones have differing overall spectral sensitivities whereby the maximum sensivity of the rods is at a lower wavelength than that of the cones. Colour is not solely a property of objects, but results from an interaction between radiant energy and the visual system. The psychophysical relationships are complex (6), and there apparently is not an established method for predicting the relative contrast of items of differing illumination, reflectance, and spectral content in the mesopic range of vision.

Vision is the primary sense required for driving, and has been examined in this respect by many researchers (e.g. 5,7). Visual aspects of night driving have attracted particular attention due to the increased hazards (8,9). There have been many experimental studies of the limits of night driving vision (10,11) and empirical-theoretical investigations have attempted to predict visibility from motor vehicles at night (12,13), that together illustrate many of the difficulties and uncertainties inherent to this subject.

What a driver may see is also affected by the night adaptation of his eyes, whereby their sensitivity increases asymptotically over a period of many minutes, but then decreases very rapidly on exposure to bright light (3). The eye's sensitivity is determined by adaptation to an overall level of illumination; since the driver's visual field includes areas of widely varying luminance that change dynamically as the vehicle proceeds along the road, contrast sensitivity also varies over time.

Most efforts at the presentation and recording of night images have concentrated on obtaining the brightest, clearest or in some sense "best" image, whether for surveillance (14), commercial photography (15) or art photography (16), with very little consideration of its correspondence to an observer's perceptions of the scene.

It is difficult in the extreme to produce a photograph from the driver's seat that accurately illustrates both the well-lit foreground and the almost-unlit areas of the field of view. A photographic print cannot provide the same range of luminance as the eye can accommodate. The problem is accentuated by point light sources such as background streetlights, or the headlight glare of a facing vehicle.

Light entering a camera is converted into a colour print image by chemically altering three layers on the film, and then on the paper, of differing spectral sensitivity. This is analogous, but not identical, to the process involving three types of colour-sensitive cones recognized in the eye. Colour distortion in a night photograph, relative to the perceived scene, also may be anticipated: the colour sensitivity in film does not diminish at low light levels in the manner that it does in vision; the film cannot easily be balanced for the ambient lighting characteristics; and the different colour emulsions will be affected to differing extents by use of the film beyond its linear response range. Established photographic calibration methods (17,18) cannot be used because an observer's perceptions at night differ from those in the good lighting conditions under which the print is to be assessed.

This brief discussion of the wide-ranging, although far from comprehensive, literature review indicates that no photograph can purport to be a totally accurate replica of an observer's perception under night conditions. However, the extensive use of charts, such as the Snellen eye test chart, and photographic resolution test targets (19) indicate that the use of a suitably designed target in the field of view can be used to produce a faithful representation of that target, and it may be hypothesized that the object of interest will then appear in the image as an acceptable representation of the observer's perception.

PRODUCING A PHOTOGRAPHIC REPLICA

A series of signs is used in the part of the scene of interest to establish the threshold of visibility of the "observer", the person viewing the scene for this purpose, under pertinent lighting conditions. The signs have a black background and ten different symbols each having a distinct reflectance. A photograph of the area, including the chosen signs, is printed at a variety of densities. The print in which the signs signifying the limit of visibility are barely recognizable, corresponds best to the actual overall view of the scene.

THE METHOD -- The use of symbols of varying reflectance on a matte black background allows the signs to be positioned at the objects of interest and thus, to have the same illumination. Differing symbols randomly displayed permits any potential for observer bias to be minimized.

Ten reflectance levels for the symbols were established at nearly equal density intervals between white and almost black, with reference to a Kodak grey scale and by a little experimentation adding black paint to a white base. At given ambient illumination, the symbol luminance depends on its reflectance. As reflectance is reduced (corresponding to increasingly dark tones of grey) the symbol is progressively more difficult to see until, at a certain contrast relative to the background, the eye can no longer distinguish it sufficiently well to identify it. Under the pertinent lighting conditions, this grey tone defines the threshold contrast. Each grey tone is taken to have a "contrast number" having an integer value between 1 and 10 from lightest to darkest. Findings obtained in using signs from two different sets in pairs, indicate that a finer division of the grey scale would not produce a better photograph.

Five alphanumeric characters and their reverse images, having apparent similar complexity involving six or five bars in the seven-bar rectangular format, were selected as the set of symbols (Figure 1). Two of the reverse images are identifiable as other characters. The symbol set is comparable with characters used by others as targets for resolution tests (19). Dissimilar recognizability of the symbols has not been a significant factor in findings obtained using the signs. After very little practise, observers were able to recognize the reverse symbols as readily as the more common characters.

The symbols have a stroke width of 90 millimetres, a height of 540 millimetres and a width of 360 millimetres, and are on a 600 by 400 millimetre background. The height and width were selected relative to the stroke width, with consideration of aesthetically preferable proportions. The stroke width was chosen with consideration of the normal visual acuity of one minute taken for well-lit, high-contrast Snellen-type eye charts. An equivalent viewing distance of 300 metres in moderate illumination was assumed. The reduction in resolution in night scenes estimated from findings by others (5,20) has been proven to have been accurate, in that the signs have been found to be useful for observations at distances of more than 100 metres to as close as 30 metres from the objects of interest.

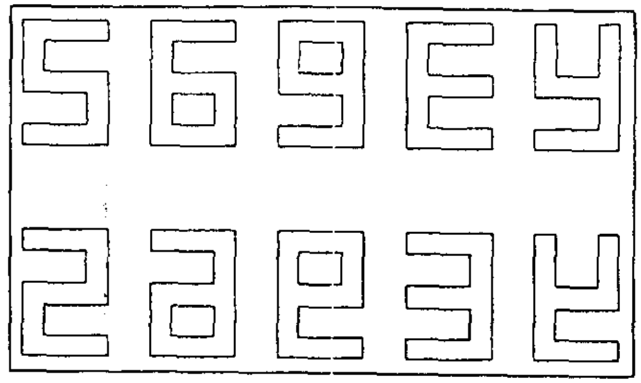

Figure 1: The set of symbols

The signs were made from three millimetre thick fibreboard. They are coded for the contrast number along the grey scale, the symbol identification and the sign set. They are stored in sequence, in a case that includes a slot at the front for display of the selected unit. The case also includes a pair of half-width, hinged doors on the front for control of the display time. Use of the signs under the same conditions, except with viewing periods of roughly one half second and ten seconds, revealed very little difference in the ability of an observer to recognize the symbols.

The signs can be employed in a simple fashion, by displaying a number of them together or in sequence, for the observer to select the one which signifies the limit of visibility. This might be useful for a careful, independent observer but the substantial potential of a biased result is obvious. A major benefit is realized by display of the signs, one at a time in no recognizable sequence, for attempted identification by an observer who was involved in a specific incident under investigation. In this situation, two sign sets are used, each including the ten symbols (Figure 2) in no particular sequence with regard to the contrast numbers but not having any symbol at the same contrast number as that of the same symbol in the other set. The use of signs displayed randomly from two sets minimizes the possibility of the observer being influenced by

Figure 2: One set of signs

an expectation from an easily-remembered sequence.

The display cases are positioned at the appropriate elevation as close as is practical to the objects of interest. A sign is selected from either set, not necessarily alternately, and is placed in either case in an irregular sequence while the view of the observer is masked. The sign is exposed to the observer for the appropriate period. The determination by the observer and an assessment of certainty are recorded in a tabular listing and a graphical format by which the trend of the sequential observations is apparent. The process is repeated until the results define the signs, one from each set, that signify the threshold of visibility for the observer. A prepared form is helpful for this purpose (e.g. Figure 3).

For the first phase of the method, any controllable artificial lighting is adjusted to the correct location, intensity and direction; and the observer is positioned in the relevant setting until the end of a period for eye adaptation to the low-level illumination. The objects of interest do not have to be present. It may be desirable to have them absent if the observer was a party in the incident and there is a possibility that the testing might affect the recollection of the matter. Otherwise, it is preferable to have the objects in place for viewing with the signs, to accommodate a secondary assessment of the photograph selected later, as desired. The recording of specific details about the conspicuity of the objects is helpful in this respect, as well as being useful for a simple description of the extent of visibility.

One person records and monitors the observations, selects the signs for display, and decides when sufficient signs have been displayed to determine the limits of visibility. One person communicates the observations to the area of the signs by radio. This can be the observer but, preferably, is an intermediary who also can assist in the control of the view of observer as necessary. At least one assistant in the area of the signs is quite helpful.

For the second phase, any involved artificial lighting remains at the correct location, intensity and direction; the signs signifying the threshold of visibility, are placed in the correct positions; and the observer is replaced by a camera. A 35 millimetre camera and 400 ASA colour film can be suitable but a larger negative format and professional film may be preferable. The lens focal length is that which, in conjunction with the print size to be obtained, will produce a print that, at the preferred viewing distance, would be an overlay of the scene. An incident light reading is obtained at the area to be photographed and the camera exposure is set accordingly, to obtain the best resolution in the film. Photographs also are taken at one f-stop increments for two greater and two lesser exposures. If the signs will be a significant distraction in the illustration of the scene to others, the photography is repeated with the signs removed. Encoding of the negative frames by a camera data back is desirable, particularly for photography in various set-ups. Professional photography may be beneficial.

In the third phase, the film is developed and printed with no adjustment in the print density. The negative with the best resolution is determined from examination of the prints. That negative then is printed at a selection of density levels in a sequence that suitably brackets borderline legibility of the symbols. If the objects of interest were photographed with the signs absent, the corresponding negative is printed similarly in the same processing. The print density increments are not precisely linearly comparable to film exposure increments but there is a similarity in general. Prints at density levels approximating half f-stop film exposure increments are likely to be suitable but will exhibit distinctly discernible differences such that a finer division may be desirable.

The final phase of the method involves selection of the photographic print in which the signs that signify the threshold of visibility for the observer, are barely discernible when viewed at the correct distance under appropriate lighting (print image shadow detail will vary significantly even between different "normal" lighting conditions). This phase can be done by the investigator without the observer if that person might be inclined to make a biased selection, perhaps because of involvement in the incident.

CONDITIONS AND CONCERNS AT THE SCENE -- While the first phase of testing is underway, the investigator usually also assesses the limits of useful perception of an object of interest by the observer. Considerable care is necessary in undertaking such assessments, and is essential if the observations and photographs are to be related to an earlier incident. Some of the circumstances to be considered are listed:

NIGHTTIME PERCEPTION OBSERVATIONS FOR PHOTOGRAPHY

FILE:				DATE:				PAGE:
OBSERVER:					START:		FINISH:	
	LEFT SIGN (as seen by observer)				RIGHT SIGN (as seen by observer)			
#	SIGN	OBS.	?	COMMENTS	SIGN	OBS.	?	COMMENTS
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								

	LEFT SIGN GRAPH											RIGHT SIGN GRAPH										
	✓											✓										
	✗											✗										
CONTRAST		1	2	3	4	5	6	7	8	9	10		1	2	3	4	5	6	7	8	9	10

DEGREE OF CERTAINTY: At ?, enter "D" for definite, "P" for probable, "M" for maybe, or "X" for no selection.

CONTRAST GRAPH:

----CORRECT (✓)-----		--------------INCORRECT (✗)------------		
D or P	M	1 of 2 signs correct	6 of 7 bars correct	Others

Figure 3: Form for recording sign observations at a site

- the safety of the observer, occupants in passing vehicles and the test personnel;
- the position and orientation of the object to be viewed and photographed;
- the state of the object, including the cleanliness of any reflector on it;
- the suitability of the foreground and background to the object of interest;
- ambient illumination, including that from the moon, streetlights, building lights and reflected glow from urban areas;
- snow, rain and fog that might affect the relative contrast of the object in the scene;
- for lighting by a vehicle, the vehicle type and loading, and the age, cleanliness, aim, setting and operating voltage of the headlights;
- for the view from a vehicle, the condition of the windshield;
- shielding the observer from the scene during changes, and from glare from passing traffic.

The headlights of a vehicle facing the observer's position may be an important part of the scene. The relatively very bright lights cause veiling glare for an observer, due to light scatter within the eyes, that reduces the visibility of the remainder of the scene. To a different extent, they also affect a photograph by flare and local over-exposure. In preliminary testing that has been undertaken with and without headlight glare using a short symbol viewing time, the symbols were less recognizable with glare, resulting in the selection of a darker illustrative photograph which was in agreement with the observer's comments about the scene. Further investigation is needed to determine the usefulness of the method in such conditions.

FILM EXPOSURE AND PRINT DENSITY -- Early experimentation revealed considerable problems in producing a usable range of photographic prints by varying the exposure of the film between frames. The width of the range that could be obtained was limited and there was substantial loss of resolution in the prints toward the ends of the range. A darker print obtained by substantially under-exposing the film provides an unsatisfactory result, as very short exposures result in reciprocity failure, involving nonlinear chemical response of the emulsion layers, by which lighter and darker areas reduce in brightness at differing rates.

A properly-exposed negative of a fixed scene under low lighting conditions, is capable of holding more information than is visible to the human eye by virtue of its ability to accumulate the incident light over a lengthy period (exceeding the latency of the rods and cones) and so a print may be created that is clearer than is seen by an observer, often without burning out the brighter parts of the scene. A good result is obtained by printing a correctly-exposed negative at greater density by reduced exposure of the print paper. Various density levels may be obtained commercially, and an appropriate range and density level step size may be selected to encompass test requirements.

VALIDATION

While the described method of producing a representative illustration of a night scene has obvious face validity in general, consideration is given to the effect of possible variation among observers.

OBJECTIVES -- An experiment was devised to test the method using a number of subjects. Each person was required to view a scene on two occasions. During the first, the subjects acted as observers and the sign contrast numbers signifying the threshold of visibility, were established. On the second occasion, each subject chose the photograph that best illustrated the scene just viewed, from prints not showing the symbols. The density of the chosen print was compared to that of a photograph in which the symbols of threshold contrast were barely recognizable.

The experiment was used for investigation of the significance of a number of variables:

* the extent to which the density of the chosen photograph could be predicted from the threshold sign contrast number;
* the variability among viewers in the selection of a photograph in which a particular symbol is just recognizable;
* the degree of uncertainty in identification of an observer's "threshold contrast number" (threshold of visibility) in the signs;
* the scatter in the threshold contrast numbers, among observers;
* the variation in density level of photographs chosen by an observer after first and second viewings of the scene;
* the scatter in density of photographs chosen as best illustrating the scene, among observers;
* differences between the relative prominence of dissimilar objects as viewed at the scene and in the photographs.

THE VALIDATION PROCEDURE -- Eleven "subjects" (unpaid volunteers), comprising six males and five females between 16 and 58 years old were tested (Table 1), although only nine of these were available for the second part, and ten for a third part, of the experiment. Subject C had earlier involvement with the method, acting as an assistant, and helped set up the experimental scene. The other subjects, being friends and relatives of the authors, had some peripheral knowledge of the method from earlier casual discussion.

A hockey arena from which the ice had been removed from the concrete pad in the playing area, provided a suitably controllable environment. All extraneous light was excluded and the pertinent part of the white boards and background were covered. The scene was in the middle part of one end of the playing area. In the first part of the experiment, it involved only the two sets of signs against the background. In the second part, it comprised the sign cases unmoved but with their black doors closed, and a number of objects resting on the concrete pad and suspended from the end glass and boards:

- a board covered with rectangles of low lustre paper of various colours,
- a warning sign with strips of orange reflective tape on a white background,
- a mock-up of an adult, with a grey jacket, black pants and white shoes,
- a blue bicycle,
- two reflective warning triangles,
- one red, and one blue, plastic milk crate,
- two small traffic pylons.

The scene was photographed with the objects present and with a pair of symbols exposed (Figure 4). Illumination was provided by four photo-floodlights positioned out of the observers' view. These were energized through dimmer switches that were adjusted to produce a suitable intensity of lighting. A chair for the observer was placed midway across the playing area, 40 metres from the scene.

TABLE 1

The Subjects in the Validation Experiments

Sub	Age	Sex	Eye Correction	Involvement
A	16	M	None	Parts 1, 2 & 3
B	22	F	None	Parts 1 & 3
C	25	M	None	Parts 1 & 2
D	26	M	None*	Parts 1, 2 & 3
E	27	F	None	Parts 1, 2 & 3
F	33	F	None	Parts 1, 2 & 3
G	39	F	Contact Lenses	Parts 1, 2 & 3
H	42	F	Contact Lenses	Parts 1, 2 & 3
I	50	M	Glasses	Parts 1 & 3
J	54	M	Glasses**	Parts 1, 2 & 3
K	58	M	Glasses	Parts 1, 2 & 3

* Contact lens worn sometimes but not during the experiment.

** For distance only; not used for viewing the photographs.

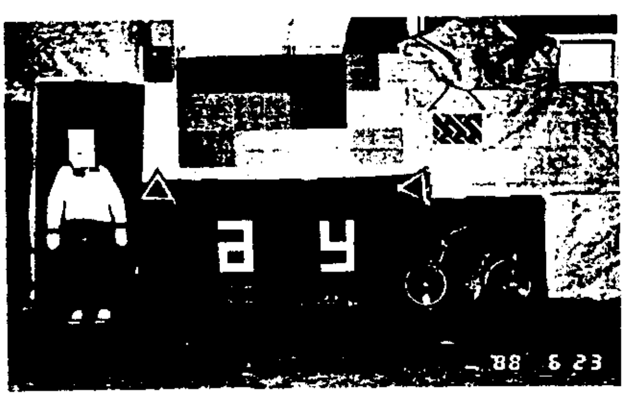

Figure 4: Objects in the test scene

Before the subjects arrived at the arena for the first part of the experiment, they received a sheet showing and naming the symbols that they would be asked to identify, and briefly describing the process in which they would be involved. When they arrived, they waited for not less than 15 minutes in an area that was darker than the viewing area. During this time, the symbols and the first part of the process were described to them by one of the experimenters.

After the eye adaptation period, the subjects were guided, in turn, to the observation position. Each waited not less than three minutes in the chair in the viewing area before the first sign was exposed for attempted identification. The process continued by the described method, with an exposure of each sign for about ten seconds, until the contrast number signifying the threshold of sign visibility was considered to have been adequately determinable.

Upon completion of part one of the experiment by the last subject, the various objects were added to the scene. The pair of signs nearest the threshold contrast for each subject were displayed in the cases and the photography was undertaken by the described method. The film was developed and prints were obtained for each pair of signs. A local photo processing centre was able to provide prints at ten density levels at regular intervals, which suitably encompassed the range of interest. These were designated from 0 to 9 in order of increasing density. Corresponding photographs of the scene with the signs hidden were prepared also.

The sheet provided to the subjects before they first attended the arena, also presented a list of the objects that would be in the scene on the second occasion, and a brief description of the second part of the efforts in which they would be involved. Upon their return to the arena, they again waited for not less than 15 minutes in the darkened holding area. During this time, the objects and the further efforts were described to them by one of the experimenters. After the eye adaptation period, each subject viewed the scene for at least eight minutes, during which one of the experimenters drew attention to each of the objects and to particular aspects of the objects.

After observing the scene, each subject, in turn, was quickly guided to a well-lighted room where the photographs of the scene with the signs hidden, were displayed. The subject chose the photograph with that density which represented the best overall illustration of the scene just viewed. Each subject also chose the photographs that best showed each of the objects considered alone. Comments by the subjects about similarities and differences between the chosen photographs and their observations of the scene, were obtained. Each subject then examined a set of photographs displaying all of the different pairs of signs of threshold contrast number at the same print density as that of the photograph chosen by that person as being the best overall illustration of the scene. The subject identified the signs that were at their limit of recognizability. The subjects repeated part two of the experiment once.

In the third part of the experiment, the photograph in which the sign at each contrast number was barely discernible, was chosen from the associated set of various density prints. This was done by the experimenters in good lighting soon after the efforts at the arena. About four months later, a similar procedure was undertaken by the ten subjects who were available.

THE THRESHOLD SIGN CONTRAST NUMBER -- The indication by the observers in viewing the signs in the first part of the experiment were charted (Figure 5). Each observer had viewed, once or more, every sign in the range of contrast numbers from that at which identification always was correct to that at which it never was correct. The narrowest possible range of contrast numbers would have been one if, for two signs in sequence, the observer had been always correct for one and always wrong for the other. Since the range of contrast numbers was more than one for every observer (Table 2), further assessment was needed to ascertain the contrast number that signified the threshold of visibility for each person.

The threshold contrast number for each observer was taken to be that at which the probability of correct identification was 50 percent. The discrete set of sign contrast numbers produced non-integral derived threshold contrast numbers (Table 3). A probability weighting was assigned for every determination by each observer and the average at each contrast number was calculated. The value was 1.0 for a correct identification made with confidence, and nil when there was no significant recognition of the symbol. Intermediate values were applied for a correct identification made with appreciable uncertainty, responses suggesting two symbols of which one was correct, and responses in which six of the seven bars of the symbol were correct. Appreciable changes in the intermediate values had little effect. The threshold contrast numbers derived by this procedure compared closely to those perceived in overviews of the charts plotted during the testing. The variation in threshold contrast number among the subjects was somewhat less than three.

VARIATIONS IN THE CHOSEN PHOTOGRAPHS -- Perceptible, although not immediately obvious, differences were apparent in prints at adjacent density levels when compared side by side. Distinct differences in prints separated by two density levels were readily discernible. (Figure 6, showing prints of the same symbols at five adjacent density levels, provides an impression of these circumstances, as limited by the further reproduction necessary for this paper.)

In choosing a photograph from prints at the ten density levels, shortly after viewing the scene, the subjects generally were quite consistent between the two tests (Table 4). Five of them chose the same photograph; only one chose photographs separated by more than two density levels. The range in density levels among the subjects was four after the first, and three after the second, viewing of the scene.

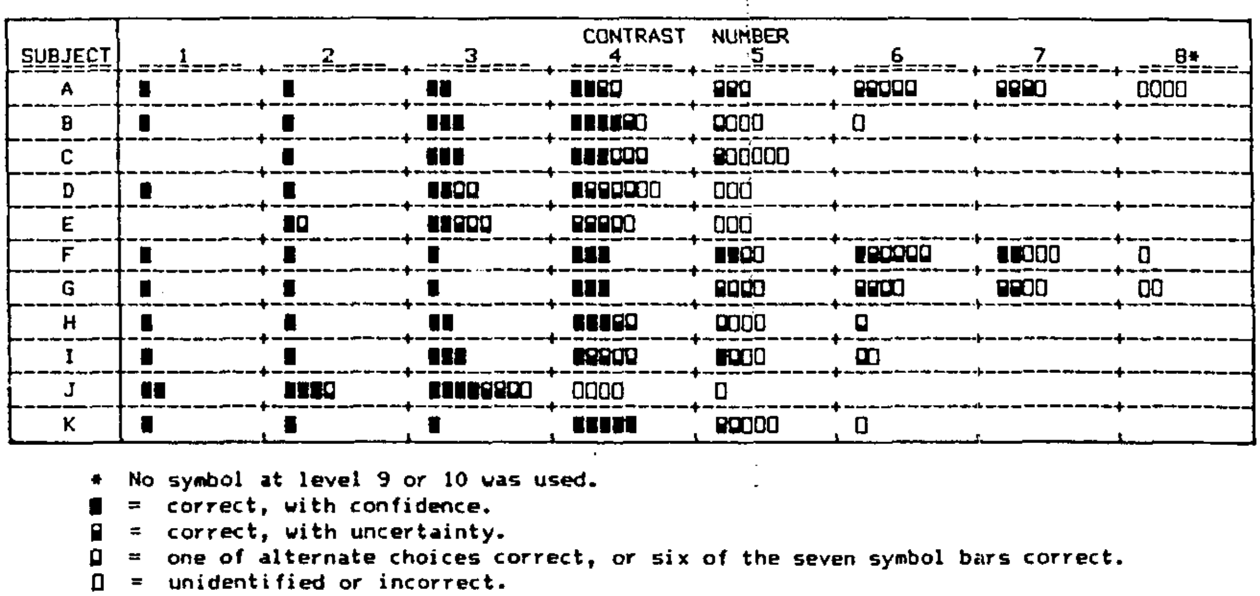

Figure 5: Graphical display of the determinations during testing of all observers (as recorded initially on the lower part of the form shown in Figure 3.)

TABLE 2

The Distribution of Subjects Among the Ranges of Contrast Numbers for Signs Always, to Signs Never, Correctly Identified

Range of Contrast Numbers	Number of Subjects
1	0
2	2
3	5
4	3
5	1
6	0

TABLE 3

The Threshold Sign Contrast Numbers

Subject	Number of Tests	Threshold Contrast Number
A	24	5.8
B	16	4.4
C	16	4.3
D	16	3.6
E	15	3.3
F	22	5.9
G	20	5.6
H	14	4.6
I	16	4.5
J	19	3.0
K	14	4.7

TABLE 4

The Photographs Chosen as Best Overall

Subject	Density Levels Chosen	
	First Trial	Second Trial
A	6	4
C	6	6
D	7	7
E	9	5
F	5	4
G	5	5
H	5	5
J	9	7
K	6	6

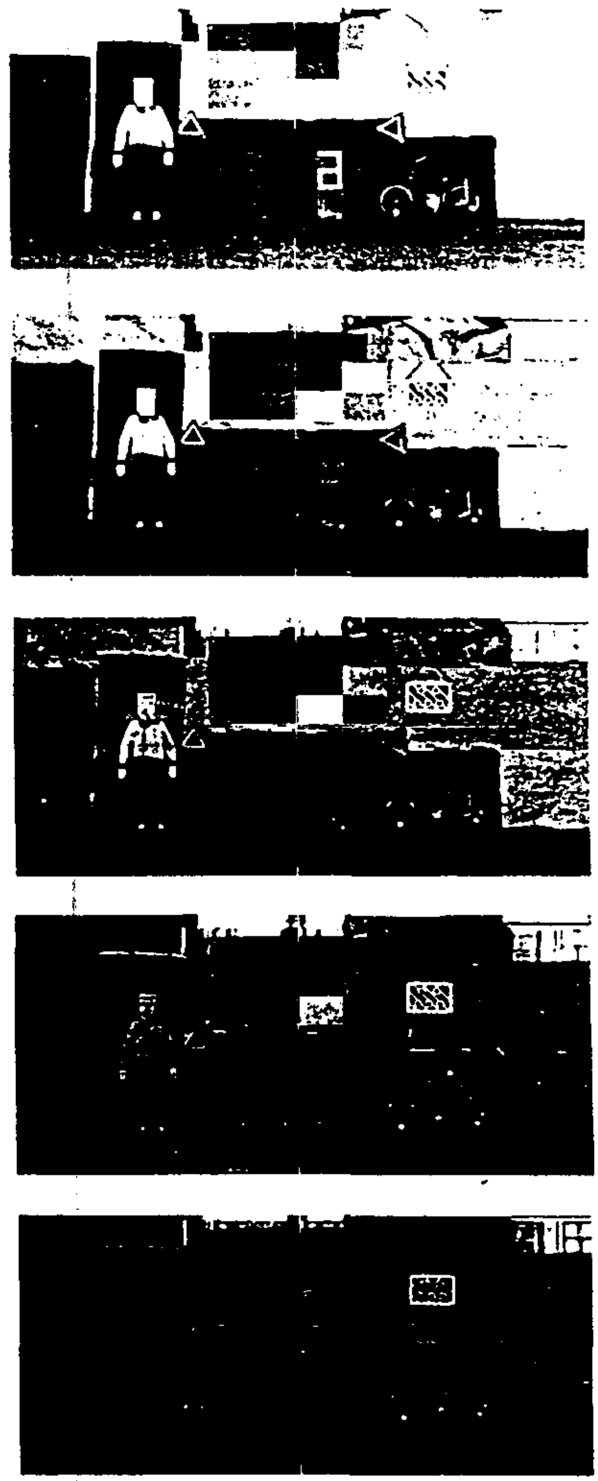

Figure 6: A photograph of the test scene, printed at five adjacent density levels

Subjects uniformly reported easily observable differences in relative appearance among the objects as viewed in the scene and as shown in the photographs. All subjects recognized that the red crate was considerably more visible in the photographs than at the scene, relative to the blue crate, and that the triangular reflectors, the warning sign and the facial features (black markings on brown paper) of the adult mock-up were far more prominent in the photographs than in the scene. In choosing the overall best photographs, the subjects tended to base their assessments principally on the relative appearance of the multi-colour board, the bicycle, the outline of the adult mock-up, and the background.

The resolution of the human eye degrades rapidly as light intensity diminishes. To obtain a photograph, additional exposure time can often be used to compensate for the dimness of lighting in a night scene. Such a photograph can show more detail than is apparent to a person viewing the night scene, even when the overall contrast of the object and background are appropriate. This may well account for the inability of the observers to perceive small details, such as the facial features on the adult mock-up, in the dim lighting, while recognizing them easily in the photographs. The highly reflective red objects, in particular, were relatively more prominent in the photographs (possibly due to the change in the eye's spectral sensitivity in dim light), suggesting that, for such objects, use of a blue filter may allow better colour matching.

THE PHOTOGRAPH PER THE THRESHOLD CONTRAST -- The three experimenters individually viewed photographs at all density levels for signs at contrast numbers between 3 and 6, and selected, for each contrast number, their best estimate of the density level at which the symbol was at the threshold of recognizability (Figure 7). As the contrast number increases (and the contrast between the symbol and the black background in the sign decreases) the density level decreases, as is to be expected. The relationship is approximately linear, with a change of one contrast number requiring a change of about two density levels.

With reference to the threshold contrast number derived for each subject (Table 3), and the mean of the experimenters' estimations of the limit density level for each contrast number (Figure 7), the "predicted density level" was established for each subject. This density level is that which the described method selects as corresponding best to that person's view of the scene.

Ideally, the predicted density level would equal the subject-selected density level in each case. Good agreement was obtained (Figure 8); the greatest difference was 1.3, and the mean difference was only 0.8, density levels. There was no obvious bias towards predicting density levels higher or lower than those chosen by the subjects.

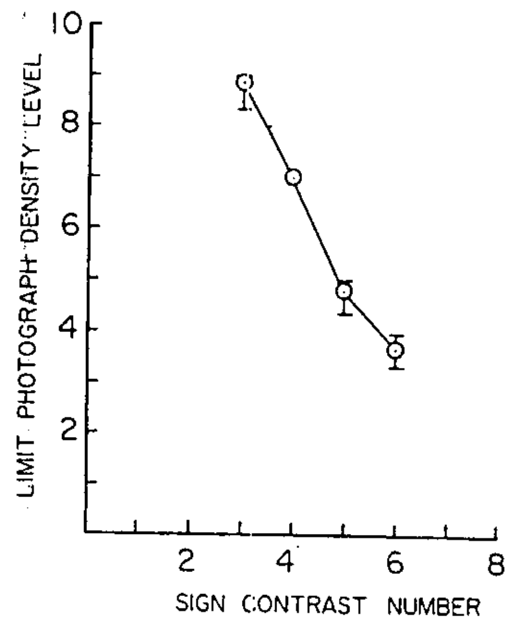

Figure 7: Photograph density level at the limit of legibility of signs of different contrast numbers, as determined by three experimenters.

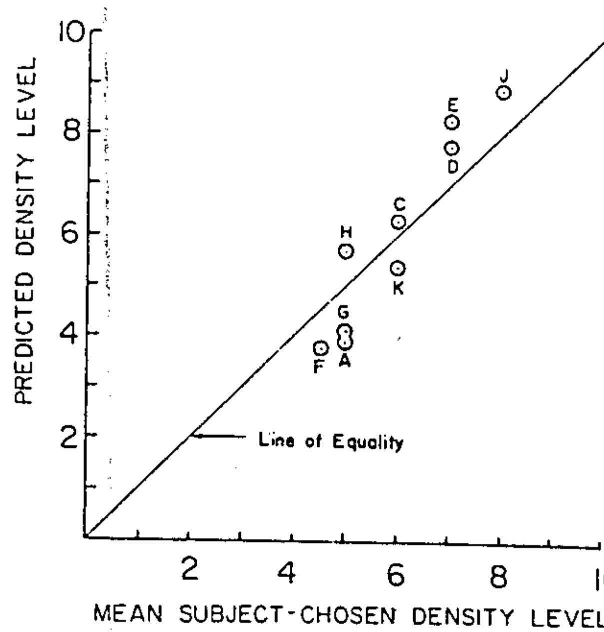

Figure 8: Comparison of the photograph density level predicted by the experimenters for, and the mean density level chosen by, each subject as best representing the scene.

Eight of the nine subjects who completed all prior testing, were available and selected the limit density level for photographs including pertinent signs. There was more variability between subjects than between experimenters, possibly due to the limited experience of the subjects in assessing such photographs and to some experimental difficulties. A separate set of predicted density levels was similarly derived from these observations and compared with the subject-selected density levels (Figure 9). The largest difference was still only two density levels, which in view of the test procedure indicates a reasonable correspondence. However for seven of the eight subjects, these predicted photographs were brighter than the mean densities of the photographs chosen after viewing the scene.

These findings indicate a need for care, not only in the observations at the site, but in the subsequent selection of the photograph. Lighting and viewing distance should correspond to those in which the photograph is to be used for demonstration.

The important conclusion to be drawn from the validation tests is that the method will usually produce a photograph that is a reasonable representation of a dependable person's view of an object in a night scene. Close consideration of the results during attempted identification of the symbols displayed at the scene, should allow an accurate assessment of the reliability of the person's observations.

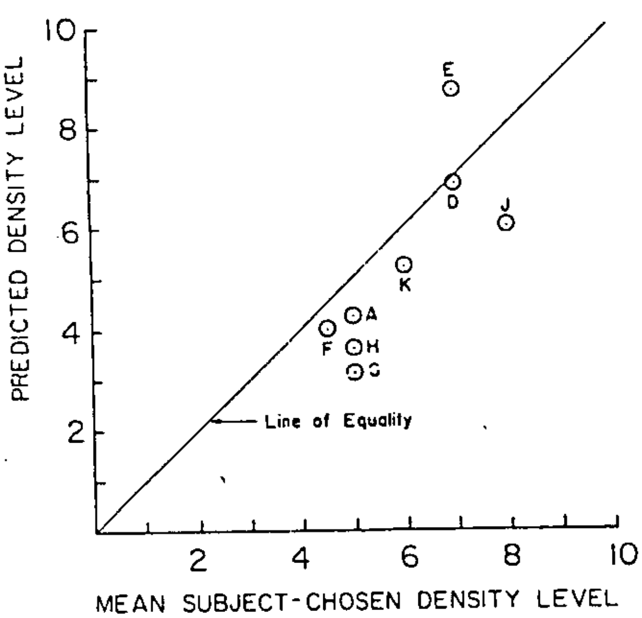

Figure 9: Comparison of the photograph density level indicated by the selections of each subject with reference to the signs shown in the photographs, and the mean density level chosen by that subject as best representing the scene.

DISCUSSION

The testing demonstrated that there is variation among observers, so that any undertaking of this nature should carefully consider the vision of the person whose view is under consideration. It is obviously best to use that observer, if at all possible. Since such a subject is potentially biased, the use of the sign sets make it much easier to complete objective perception observations, as well as to produce matching photographs.

The testing indicated areas of variability that render a perfect match impossible. The determination of the threshold sign contrast number is open to some judgment as there is not a clear transition from perfect visibility of one sign to perfect invisibility of the next. There is uncertainty in the identification by some subjects of the density level for the photograph best representing the scene. There is substantial variation in the relative prominence of different objects viewed directly and in a photograph. This dictates a need for close attention by the investigator to minimize deviations and to recognize the possible extent of those that may remain. The photograph that is provided for illustrative purposes must be explained accordingly.

Careful use of the method produces a photograph that has a substantial likelihood of being within one density level of the choice that would be made by the observer if it were possible to view the photograph and the scene simultaneously for comparison. An observer other than the person who was involved in the incident, necessitates an assessment of the extent to which the observer's vision is "representative" or comparable to the involved person. Even with such other observer, the method can produce a photograph that is demonstrably similar, in general terms, to a subject's static night view of a scene.

Further verification of a photograph produced in this manner may be obtained by recording specific comments from the observer about the relative visibility of various objects. Caution is necessary regarding small objects or details (as photograph resolution exceeds that of the human eye at low light levels) and objects with colours that are likely to have a substantial effect on their relative prominence in the view of the scene and the photograph.

DYNAMIC VERSUS STATIC OBSERVATIONS -- Static perception conditions do not necessarily correspond to the view of a driver in a vehicle moving at highway speeds, since the continually changing field of view limits the driver's ability to recognize unusual obstructions. An investigator has the problem of selecting the position at which the subject can see an object sufficiently clearly to recognize it as a hazard. The method has been used for only very limited investigations in this regard. During one investigation with a single subject, it was found that there was no significant difference in visibility of signs at various contrast numbers between viewing times of about one half second and ten seconds. In another instance, a driver moving at a moderate speed toward an object, following extensive sign contrast observations, was able to respond to the object by braking before reaching the statically-determined point of threshold visibility. It is suspected that this may have resulted from increased visibility distance due to road roughness and headlight bounce, but further investigation remains to be done.

A further, important, consideration is the difference between the perception of an unalerted driver of a vehicle approaching an object at a substantial speed, and that of the same person in a stationary vehicle, viewing the same object after knowing it is there. The literature contains a considerable number of investigations of dynamic driver perception, although very scattered results are reported that appear at least partially attributable to the method of determining perception. A permanent record of a driver's dynamic view is difficult to imagine, after consideration of these efforts to record his static view.

SUMMARY

A method has been developed that provides a means of preparing a photographic print that, to a reasonable degree, objectively illustrates the appearance of a night scene to an observer. Such a photograph may be desired to show others the results of an investigation of problems associated with a nighttime collision. Much of the subjective assessment usually required has been removed by the use of a variety of signs of differing shades of grey.

Limited validation studies have identified significant differences in perception between observers, but have demonstrated that these are appropriately recognized by the method. While the testing did not encompass a statistically representative number of subjects, it was able to predict an appropriate photograph for each, that closely matched the subject's judgement. Difficulties were identified, including imbalance between objects of differing luminance and colour (which may be reduced by professional photography).

The results to date are sufficiently good, and sufficiently better than the existing alternatives, that the method may usefully be applied when the need for such illustration arises.

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Emergency Lighting Systems

On the evening of February 14, 2001 three emergency blinking lighting systems were tested by the SSCC Committee members. Following is a brief analysis of those results.

1. Sno-Glow Product: Installed in an Arctic Cat.
   A. The installation of the product impacts on the lenses in both the tail light and the headlamp of the vehicle.
   B. We do not know what the photometric ratings are of the product, nor do we know how it impacts on headlight photometrics.
   C. When you lift the hood, it completely diminishes the Sno-Glow headlamp since it points it down to the ground.
   D. Sno-Glow definitely alters the electrical systems within the snowmobile.
   E. At close range, the headlamp blinking light is not bright. It does show well at 3/10 of a mile.
   F. There is very little lateral view of lights blinking using the Sno-Glow product.
   G. The rear taillight does show at 3/10 of a mile blinking while no headlamp is on the taillight. When a headlamp from either a snowmobile or a car headlamp is approaching the snowmobile from the rear with the Sno-Glow product operative, there is no blinking discerned. The reflective ability of the taillight serves in exactly the same purpose as the Sno-Glow product with no discernable difference in visibility.

2. Arctic Cat Blinking Light product:
   A. It has a 360-degree visibility rating at 3/10 of a mile.
   B. It is attached using a clamp to the top of the windshield, which allows visibility from greater distance and could then be seen if it was in a ditch or in a culvert.
   C. The light can be affixed directly above the snowmobile from a tree or fence, allowing someone to see where the snowmobile was.
   D. You can see the blinking light at all times when approaching the snowmobile from 3/10 of a mile.

3. The Ski-Doo light product:
   A. Visible at 3/10 of a mile but does not have 360-degree visibility. It is only visible straight on.
   B. It does have an S.O.S. blink as well as a constant on and then a normal blinking light.
   C. It can be affixed to the top of the windshield allowing greater visibility and could also be affixed to a tree or fence adjacent to a disabled snowmobile.

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October 23, 2001

Al Lakosky, President
Snow Glow Inc
312 2nd Ave North
Virginia, MN
55792

Bombardier Inc.
565 de la Montagne
Valcourt, Québec, Canada J0E 2L0
Telephone 1(450) 532-2211
Fax 1(450) 532-5032
http://www.recreation.bombardier.com

EMERGENCY FLASHER SYSTEM BY SNOW GLOW INC.

Dear Al,

Thank you for demonstrating your interest in the sport of snowmobiling.

We tested the "Emergency Flasher System" kit during winter 2000 on a Grand Touring 600 model year 2000. The snowmobile totaled around 4500 km during the season. Many different operators made use of the snowmobile during this period.

Test results are enclosed in the following addendum in which we have listed several concerns related to the system, its installation and its usage.

We found no evidence that would support the use of such "Emergency Flasher System" and therefore, we regret to inform you that we are not interested and that we will not pursue the evaluation.

Sincerely yours,

Guy Hétu
Project Leader

Cc: Michel Baril
Bernard Guy

Addendum

Kit

Snow Glow Inc supplied Bombardier Inc. an "Emergency Flasher System" kit. There was no instruction sheet for installation of the system for Ski-Doo products. The instructions supplied were for Polaris snowmobiles.

We installed the system to the best of our knowledge as well as using the instructions written for the Polaris application.

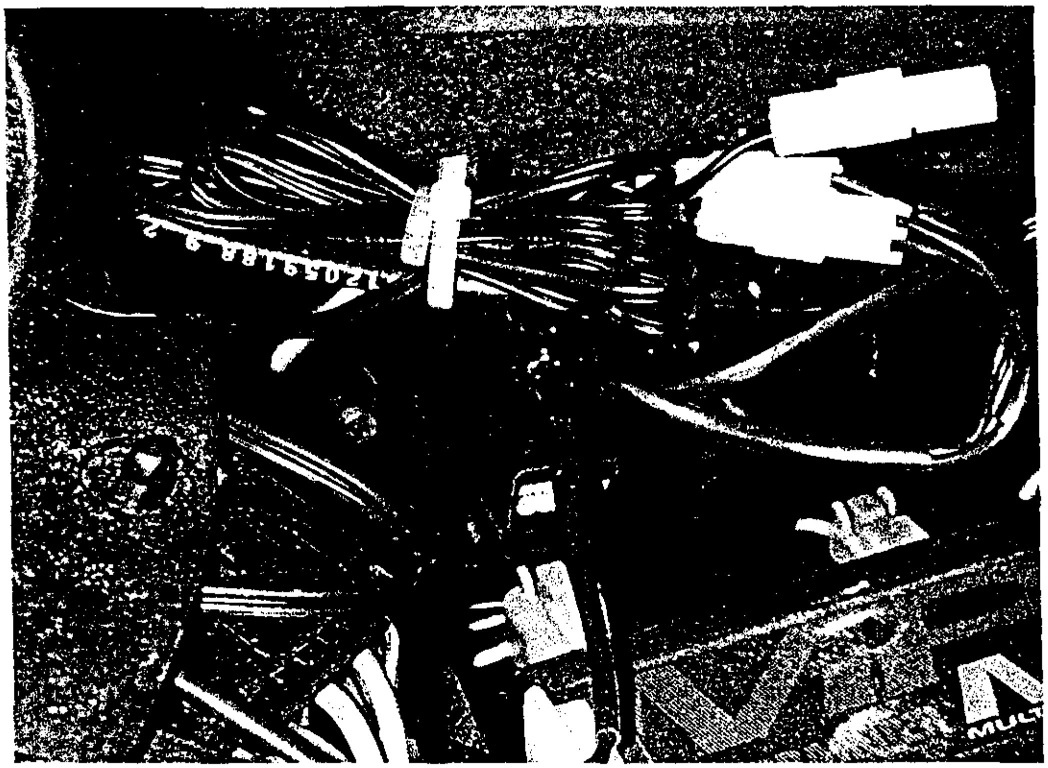
The kit components were:

1	Lithium Battery Pack
1	Toggle Switch Harness with Toggle Nut
1	Black Toggle Boot
1	Indicator LED Harness
1	10mm Laser Bright, Red Led
1	10mm Laser Bright, Yellow Led
2	Short Coarse Thread Self Tapping Screws
2	3" Screws
2	1.5" Screws
3	Nuts
10	Tie Wraps

Installation

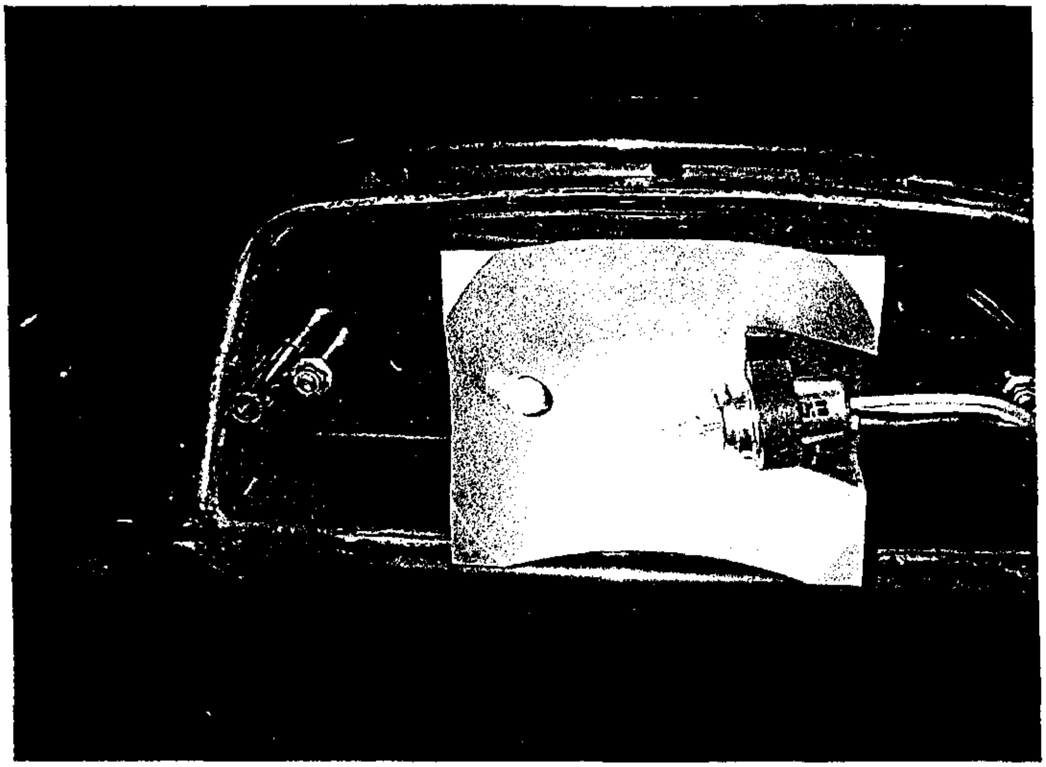
Wiring installation to the front headlight and to the rear tail lamp took about 5 hours due to the fact that we had to disassemble many components to run the electrical wiring such as: Air Box, Seat, Console, Wiring Harness, etc.

We installed the "Lithium Battery Pack" on the air box in order to have better access.

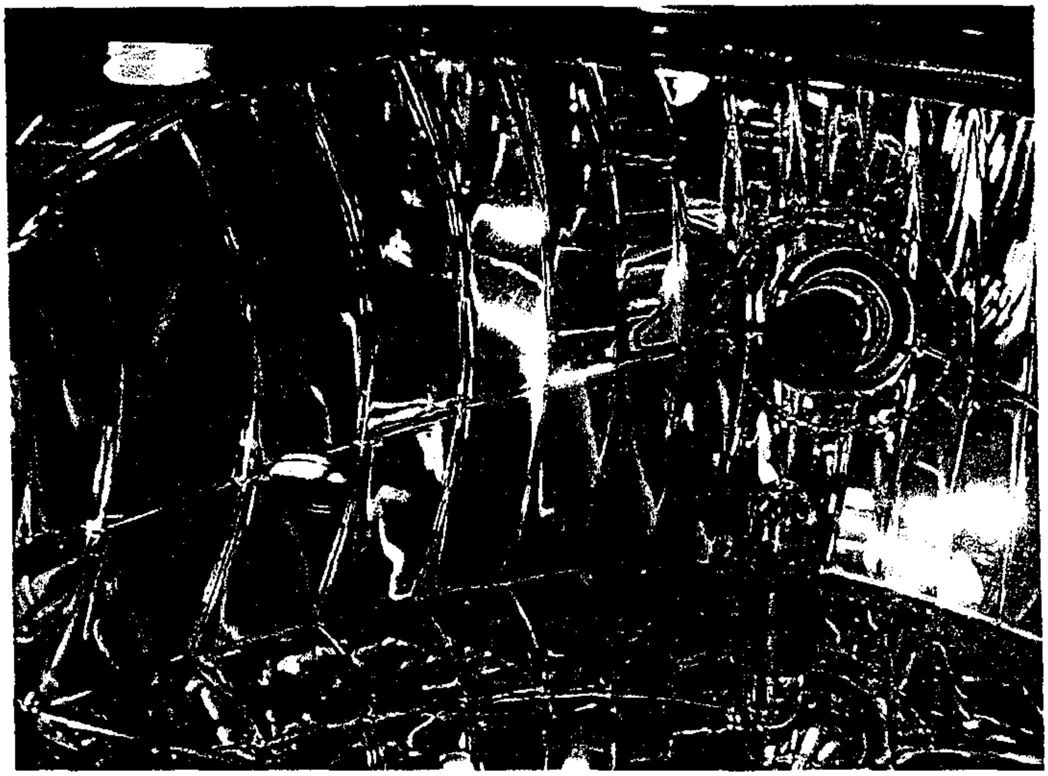


The "Toggle Switch" and Led indicator were installed on the right side of the console.

We used our best judgement to position the "Laser Bright Light Red Led" which was installed across the rear tail lamp.



Concerning the "Laser Bright Yellow Led" we installed this component on the lower flat surface in the center widthwise, and as close as possible to the front headlight reflectors.



Test
The kit was used on a Grand Touring 600 snowmobile, 2000-model year. The snowmobile totaled around 4500 km during the season. Many different operators made use of the snowmobile during this period.

Results
During the winter season, there was an intermittent drop in lighting intensity by about half of its original value. We were unable to determine the cause.

It should be noted that the wiring does not respect our Engineering Standard with respect to insulation, abrasion, etc.

Moreover, we do not recommend modifying or altering components neither in the front headlight nor in the rear tail lamp due to the fact that both these components are built to meet strict SAE standards according to SSCC and CMVSS 1201. The LED contained in these components creates an obstruction than may have an effect with respect to lighting reflectivity.

System evaluation

Many people were able to evaluate the system from many distances and relative positions. Detection of the red LED in the tail lamp is difficult considering that the colors become confounded with the reflectivity coming from the rear lens reflectors. So, visually the rear lens reflectors alert all approaching vehicles that are equipped with a headlight.

Detection of the yellow LED in the headlight is perceptible at a range of approximately 300 meters. However, the yellow LED becomes no longer visible each time we open the hood – which is frequent in the cases of repair work when the sled is immobilized.

Conclusion

Bombardier Inc. offers a portable light signal 295 500 544. This light signal, sold as an accessory, is designed with multiple functions and possible mounting positions on the snowmobile or elsewhere in the vicinity. We feel that it is a more versatile accessory than the Snow Glow system, which is permanently installed on the snowmobile.